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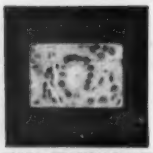

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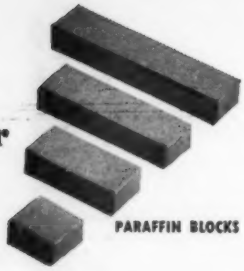

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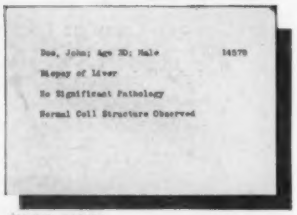

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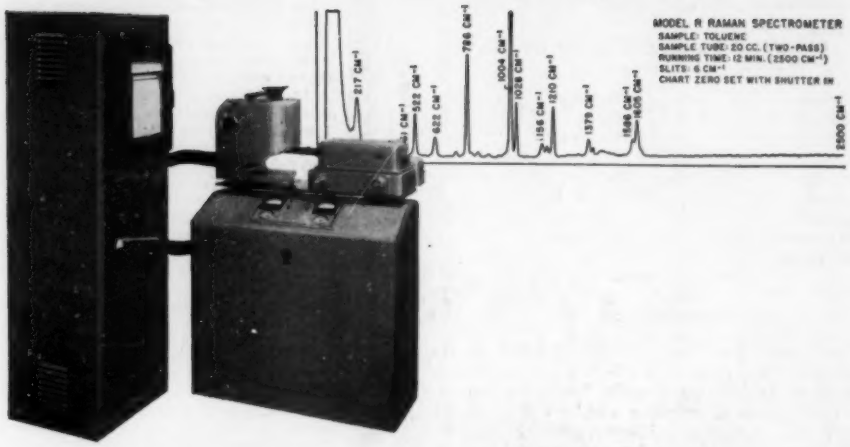

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The AAAS also publishes THE SCIENTIFIC MONTHLY.

Science Changes

This issue of *Science* starts not only a new month and a new volume but also a new format. The most obvious changes are the increase in over-all page size, a text page of three columns instead of two, the combination of "Technical Papers" and "Communications" into a single department, and the new department in which all material on scientific meetings is assembled.

The principal reason for the change of page size is the expectation of greater income—income that can be used for the larger and stronger, and hence more expensive, editorial staff that can make *Science* into a more useful journal. Like many another periodical, *Science* depends on advertising revenue for a fair portion of its budget. For a wide range of advertisers, *Science* is a good advertising medium. But many of these advertisers were handicapped, and sometimes frightened away, by our nonstandard page size, for many already designed advertisements had to be remade to fit a *Science* page. Advertisers, advertising space salesmen, printers, and publishers were unanimous in advising the change and in predicting a larger advertising revenue if we made it possible for companies that advertise to scientists to use in *Science* the standard-size plates that can also be used in other journals.

Changing size and format created an opportunity to make typographic improvements. Over the years, *Science* had gradually become a typographic hodge-podge in which half a dozen different type faces had been mixed together in ways that would be hard to justify. In the new format the variety of type faces is greatly reduced.

All these changes have been made with good supporting reasons. Nevertheless, a few complaints are inevitable. Changing the size of a journal is always a nuisance to librarians and to others who like to keep uniformly bound sets. To them all we apologize. There will probably be some complaints simply because there are changes, complaints that may echo those of several decades ago when *Science* abandoned the page size to which it is now reverting in order to adopt the size it is now abandoning. To those who dislike any of the current changes we also apologize.

As a matter of fact, however, there have been several changes in page size and quite a number of changes in format, external appearance, and organizational and typographic details in *Science*'s 121 volumes. There may be others if future conditions indicate their desirability. For the time being, we have changed page size, largely to attract additional advertising but also to present more editorial matter on a given amount of paper. We have changed the number of columns per page to give greater flexibility of layout and have made the typographic changes to improve appearance and readability. It is our purpose to follow these changes with the more important editorial improvements that both the readers and the editors of *Science* would like to see.—D.W.

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The Chloroplast as a Complete Photosynthetic Unit

Daniel I. Arnon

"Experimenters . . . never accept an immutable starting point; their principle is a postulate, all of whose consequences they logically deduce, but without ever considering it absolute or beyond the reach of experiment. All the theories which serve as starting points for . . . physiologists are true only until facts are discovered which they do not include or which contradict them. When these contradictory facts are shown to be firmly established . . . experimenters, far from stiffening themselves against new evidence, hasten . . . to modify their theory, because they know that this is the only way to go forward and to make progress in science. Experimenters, then, always doubt, even their starting point."—Claude Bernard, *Introduction a l'Etude de la Médicine Expérimentale* (1865).

The thesis that I am attempting to document in this article (*1*) is that "complete photosynthesis—that is, reduction of carbon dioxide to carbohydrates, and oxidation of water to oxygen, at low temperature and with no energy supply except visible light—" (*2*) has now been accomplished outside the living cell with the use of isolated chloroplasts. The conclusion drawn from the evidence presented is that chloroplasts are the cytoplasmic structures in which the complete photosynthetic process is carried out, both inside and, under suitable conditions, outside the living cell. Since the evidence in support of this conclusion is presented in detail in other publications from our laboratory (*3–7*), I am concerned here only with the principal results of our work and with a review of other experiments on extracellular photosynthesis, chiefly those in which chloroplast preparations have been used. I have not attempted to review the numerous reports (*2*) of "artificial photosynthesis" with chlorophyll solutions, dyes, or other "sensitizers."

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Photosynthesis in Chloroplasts

That chlorophyll is essential for photosynthesis was first clearly and unequivocally stated by Sachs in 1865 (*8*) almost 100 years after the discovery of the process. Of course, the association of green plants with photosynthesis had been obvious to physiologists during the preceding century, but even Theodore de Saussure, whose classical treatise (*9*) marked the beginning of modern concepts of plant nutrition, was misled by the red color of many leaves to question the indispensability of chlorophyll for assimilation of carbon dioxide in light. Sachs condemned the cautious belief of his contemporaries, that "*green plants* decompose carbonic acid," by insisting that it was chlorophyll, or more properly the "chlorophyll-body" or chloroplast, that was the organ of CO_2 assimilation in light. When it was argued that since chloroplasts carry on photosynthesis only when present in the living cell and, hence, "not the chlorophyll (chloroplasts) but the cell containing chlorophyll is the organ of assimilation," Sachs' reply was that this is "somewhat equivalent to saying that the eye is not properly the organ of sight, since, when taken out of the head, it is no longer capable of seeing" (*10*).

The basis for Sachs' firm stand that the "chlorophyll-body itself [is] the organ which decomposes carbon dioxide and consequently assimilates the organic substance" was the fact that "no cell assimilates so long as it possesses no green chlorophyll, but does so as soon as it is provided with it. The most definite proof, however, is afforded by the fact . . . that the first recognizable product of assimilation [starch] appears not in any haphazard place in the [green] cell, but in the chloroplast-body itself" (*10*). Sachs' conclusion, which was based on his classical experiments on starch synthesis in light, soon received a strikingly direct confirmation. In 1881, Engelmann (*11*) showed that the "eye" in Sachs' simile could still see after its removal from the "head." He succeeded in isolating chloroplasts from several species of green plants and demonstrated, for the first time, oxygen evolution in light by chloroplasts outside the living cell. To demonstrate oxygen evolution, he developed an extremely sensitive microscopic technique: the motility of certain bacteria in the presence of minute traces of oxygen (*11*). With the same test, he was also able to show that in the intact, illuminated *Spirogyra* cell oxygen evolution is confined to the immediate vicinity of the chloroplast (*12*).

The evolution of oxygen by isolated chloroplasts, confirmed by Haberlandt in 1888 (*13*) and by Ewart in 1896 (*14*), was then accepted as the most direct evidence yet found that the role of chloroplasts in photosynthesis was that envisaged by Sachs. In 1897 one of the most distinguished plant physiologists of the period, Pfeffer, expressed thus (*15*) what was to become a fixed tenet in plant physiology for the next 40 years: "The actual assimilation of CO_2 probably takes place entirely in the chloroplastid, for by means of the delicate bacterium-method it may be shown that isolated chloroplastids occasionally continue to evolve oxygen in the light . . . if placed in an isoosmotic sugar solution."

Extracellular Photosynthesis

The early experiments of Engelmann and his successors were not designed to test whether photosynthesis could be carried on outside the living cell. The philosophic outlook of biologists of that period on the possibility of reproducing a complex biochemical process outside a living cell was dominated by Pasteur's

views on fermentation. After the publication of his famous paper in 1857 (*16*), Pasteur maintained throughout his life that fermentation is dependent on the life and integrity of the cell and that it does not occur in the absence of the living cell. Engelmann's experience with isolated chloroplasts fitted in with this pattern of thought. His results did not suggest to him or to his contemporaries the possibility of extracellular photosynthesis. He found that isolated chloroplasts could carry on oxygen evolution, for a limited time at best, and only if their structure remained undamaged. Engelmann summed up his conclusions in what was to become an often quoted dictum: "Sobald die Struktur des Chlorophyll Körnes überall zerstört ist, hört die Möglichkeit der Sauerstoffproduktion sofort und definitiv auf." It seemed clear, in the words of Pfeffer (*15*), that "the assimilation of carbon dioxide is a *vital* function, the chloroplastids being living mechanisms specially adapted for this purpose." This conclusion also agreed with many observations that damage to whole leaves—such as that resulting from drying, freezing, or boiling—results in cessation of photosynthesis.

Pasteur died in 1895. Two years later Büchner (*17*) prepared from yeast a cell-free juice that fermented sugar. Compared with the cells from which it was derived, the juice was weak and its activity short-lived. Nevertheless, Büchner's experiments electrified the scientific world at the time, for they demonstrated that—Pasteur's great authority notwithstanding—complex biochemical reactions could be carried out by enzymes in cell-free systems. It was only natural therefore to inquire whether other physiological processes, notably photosynthesis, could also proceed with "dead" cell preparations—that is, independently of the degree of cellular organization associated with a living cell.

It was in this different intellectual climate and with this new objective in view that Büchner himself suggested in 1901 to Herzog (*18*) that he investigate whether a cell-free green juice from leaves, prepared by the procedure used by Büchner with yeast, could carry out photosynthesis under the influence of light. While Herzog's work was in progress there appeared a report by Friedel (*19*) which suggested that extracellular photosynthesis had been achieved. Friedel prepared a green powder from spinach leaves dried at 100°C and, from fresh leaves, a glycerol extract containing enzymes ("diastase"). On illumination, neither preparation alone had photosynthetic activity, but after combining them Friedel reported an evolution of oxygen that he measured by gas analysis. He concluded from his experiments that "L'assimilation chlorophylienne est accomplie sans intervention de la matière vivante, par une diastase qui utilise l'energie des rayons solaires, la chlorophylle functionnant comme sensibilisateur."

All was not well, however, with Friedel's work. In the fall of the same year he tried but failed to repeat (*20*) his experiments of the spring. He attributed his failure to an assumed low photosynthetic activity of leaves in the fall. He indicated his intent to return to the problem again, but there is no record that he ever did. In fact, he himself omitted mention of his earlier successful experiments in the thesis that he submitted to the Faculté de Paris (*21*). Other investigators, who tried to repeat Friedel's work, such as Harroy (*22*), also met with failure. Herzog (*18*), upon learning of Friedel's first reported success, interrupted, on the advice of Büchner, his own experiments and proceeded to use Friedel's methods, only to obtain negative results. Herzog then returned to Büchner's methods of extracting leaf juice by high pressure, but again the results were negative (*18*).

The only reports of successful repetition of Friedel's early experiments came from Macchiati (*23*). However, the nature of Macchiati's evidence not only failed to convince others but also threw even more doubt on the original observations of Friedel. Macchiati claimed that he had obtained the formation of formaldehyde corresponding to the evolution of oxygen. Moreover, unlike Friedel, he claimed that the green powder from leaves dried at 100°C, alone and unaided by the glycerol extract of fresh leaves, possessed photosynthetic activity. The enzyme that had been supplied in Friedel's experiments by the glycerol extract was, Macchiati claimed, heat-resistant and contained in the leaf powder. But, as was properly asked by Bernard (*21*), if leaves themselves lose their photosynthetic activity when dried at 100°C, how could the dry powder possess it? Bernard carefully reinvestigated the whole problem of photosynthesis by "dead" leaf preparations and reached the conclusion that photosynthesis outside the living organism had not been attained and that all the claims to the contrary were unfounded.

Nevertheless, the unsuccessful quest for extracellular photosynthesis during this period did not end without a hopeful note. In 1901 Beijerinck published a paper (*24*) the importance of which seems to have been appreciated by only a few of his contemporaries. He showed that luminous bacteria can be used successfully to study oxygen evolution during photosynthesis. Like Engelmann's motile bacteria, Beijerinck's luminous bacteria could be used to detect minute amounts of oxygen. Moreover, the luminous bacteria had a great experimental advantage: the test for oxygen was luminescence visible to the naked eye. Instead of Engelmann's microscopic technique, which drastically limited experimental manipulation, Beijerinck's method provided an extremely sensitive oxygen "reagent" in the form of a bacterial suspension that could be mixed readily with photosynthetic tissues. In fact, because of its far greater sensitivity than the gas-analysis or bubble-counting method, it was an excellent technique to introduce into the then current debate on extracellular photosynthesis.

Beijerinck used his new technique in photosynthesis to measure oxygen evolution, not of leaf powders, but of a green extract of fresh clover leaves. He found by this method that these cell-free extracts evolved oxygen on exposure to light. Interestingly enough, Beijerinck's philosophic predilections on extracellular processes seem to have been more akin to those of Pasteur than to those of Büchner. Beijerinck interpreted his results to mean not that photosynthesis is basically separable from the integrity of a living cell but rather that "living" protoplasm is necessary for photosynthesis. He explained the observed oxygen evolution of his cell-free extracts by suggesting that they contain a water-soluble "portion" of the living protoplasm, the portion that is concerned with photosynthesis.

What was then the distinction between a living and a dead cell? Was a cell-free extract alive? It appears that desiccation was a criterion of great importance to the investigators of that period. This is particularly apparent in the work of Molisch (*25*), who embarked on the investigation of extracellular photosynthesis in 1904 with a deep conviction that the problem was of fundamental importance. Molisch appreciated the importance of Beijerinck's work and adopted his sensitive luminous-bacteria technique. He confirmed Beijerinck's results with leaves of several species and added a significant fact: when the green extracts of fresh leaves were filtered through a bacterial filter to remove all particles, including chloroplasts, the capacity for oxygen evolution was lost. Molisch then proceeded to the heart of the matter: do "dead"—that is, dry—leaves retain a capacity for photochemical oxygen evolution? He found that, contrary to the claims of Friedel and Macchiati, leaves dried at 100°C were invariably inactive. With milder drying, however, in air or at 35°C, leaves of only one species, *Lamium album*, retained activity. Other plants, including those that gave active green extracts, lost, on drying, the capacity to evolve oxygen in light. Mo-

lisch concluded from his study that the case for extracellular photosynthesis was not proved but that the exceptional results with *Lamium* offered some hope for the future.

Molisch returned 20 years later (*26*) to the still unresolved question whether "dry, dead leaves" retain the capacity for oxygen evolution in light. This time, in an extensive investigation, he was able to show, again with the sensitive luminous-bacteria technique, that water suspensions of ground dry leaves of many species retained the capacity for oxygen evolution, provided that the drying was slow, at 30° to 35°C. Quick drying at 100°C, boiling the leaves in water, or treatment with ether, destroyed activity irreversibly. Leaves killed by freezing also retained activity. The capacity to evolve oxygen in light was limited to leaves containing chlorophyll. Preparations from gently dried, etiolated leaves were inactive. On the basis of this newer evidence, Molisch concluded that photosynthesis, like fermentation, can proceed outside the living cell. He interpreted the destructive effect of drying at high temperatures as probably resulting from an inactivation of essential enzymes.

Modern Period

The evidence for Molisch's conclusions about extracellular photosynthesis, supported by the later observations of Inman (*27*), was not considered adequate by the majority of plant physiologists (*2*). There were no quantitative measurements of oxygen evolution; there was only a qualitative test by an exceptionally sensitive method. There was no evidence for a simultaneous carbon dioxide fixation. This was merely inferred from the concept, which was dominant in theories of photosynthesis for more than a century, that the source of the evolved oxygen was the photodecomposition of CO_2. From this point of view, oxygen evolution was *ipso facto* a measure of CO_2 fixation.

In the last 20 years this concept has been abandoned. The clear analysis of the process of photosynthesis by van Niel (*28*) from the standpoint of comparative biochemistry made it extremely plausible that the source of the photosynthetic oxygen is the photodecomposition of water rather than of carbon dioxide. This view soon received experimental support from the work of Hill, who demonstrated oxygen evolution without CO_2 fixation, in light, by isolated chloroplasts. It also became evident that CO_2 fixation is not peculiar to photosynthetic tissues but occurs widely in nonphotosynthetic plant and animal cells of diverse character. Both theories were firmly documented after the advent of isotopic tracer techniques. From the modern point of view, acceptable proof for complete extracellular photosynthesis would thus require evidence for *both* the evolution of oxygen and the simultaneous reduction of CO_2 to the level of carbohydrates.

There was still another basic reason why the earlier claims for extracellular photosynthesis were found inadequate in the modern period. The old philosophic controversy about duplicating a complex biochemical sequence outside a living cell ceased to be a live issue. The spectacular advances of biochemistry in elucidating the nature of fermentation and respiration by means of extracellular reactions (the important developments came about 40 years after Büchner's historic experiment), the recent reconstruction of the principal events in the citric acid and fat oxidation cycles, and many other developments left no doubt that, in principle, photosynthesis, like any other cellular process, should be susceptible of study outside the cell. What was lacking, however, was not a demonstration that a small residual photosynthetic activity remained in cell-free preparations but a quantitative biochemical technique for the separation of the photosynthetic process from other complex metabolic activities that occur simultaneously in an intact cell.

Few contemporary physiologists or biochemists doubted that only by doing away with the complexity of a whole cell could the detailed mechanism of photosynthesis be studied and interpreted with confidence in physicochemical terms. It is not surprising, therefore, that during the last 20 years the achievement of extracellular photosynthesis has remained an important target of cellular physiology and biochemistry. The objective was no longer philosophic; it was biochemical. The criteria for judging advances in this area would be whether a particular cell-free system reproduces the complete process of photosynthesis, and whether it lends itself to a systematic, quantitative study of the mechanism of the process.

The recent approaches from this modern, biochemical point of view toward extracellular photosynthesis can be divided into two main categories. One, following the first attempts of Engelmann in 1881, centered on isolated chloroplasts; the other concerned itself with preparations of whole cells without regard to any special subcellular structure. I deal with the latter first. My review is limited to those experiments in which oxygen evolution or CO_2 fixation, or both, were measured. Extracellular photosynthetic reactions have also been investigated by other techniques such as determining changes in redox potential and *p*H of whole-leaf macerates and chloroplast suspensions (*29*).

Whole-Cell Preparations

Fager (*30*) observed that cell-free macerates from spinach leaves fixed about twice as much radiocarbon in light as they did in dark. The increased fixation in light (6×10^{-9} moles of CO_2) was estimated to be 0.1 to 0.2 percent of the corresponding photosynthetic activity of intact cells. Later Fager fractionated the leaf macerate into a chloroplast and a protein fraction, which contained the CO_2-fixing enzyme (*31*). The combined fractions fixed CO_2, again in both light and dark; the increment resulting from illumination amounted to about 50 percent.

In interpreting the relationship of his findings to the over-all process of photosynthesis, Fager attached the greatest significance to his identification of phosphoglycerate as the chief product of CO_2 fixation in light. But phosphoglycerate was also the predominant compound of dark fixation. Moreover, his chloroplast preparations were almost wholly inactive photochemically when they were tested with quinone as the oxidant. The addition of photochemically active chloroplasts failed to increase CO_2 fixation in light. It is not clear how photosynthetic CO_2 fixation could be governed by photochemically inactive chloroplasts.

Another approach to extracellular photosynthesis is found in the recent experiments of Tolbert and Zill (*32*). They extruded, with a minimum of manipulation, the entire protoplasm (whole-cell contents less vacuolar sap) from a few large (1 to 2 in. long) cells of *Chara* and *Nitella* and measured CO_2 fixation in light and dark. Oxygen evolution was not determined. When illuminated, the extruded protoplasm fixed radioactive CO_2 into several compounds, including sucrose and hexose phosphates.

The fixation was appreciable (12 to 15 percent of that of whole cells) and left no doubt that whole protoplasm retains outside the cell walls the capacity to reduce CO_2 photosynthetically to the level of sugars. Photosynthesis, however, was not separated from other cellular processes. Thus in the dark, the extruded protoplasm fixed CO_2 into compounds that were characteristic of dark respiration. The extrusion technique, although it dispenses with the structural integrity, seems to retain the biochemical complexity of a whole cell, without conferring any obvious advantage in isolation of enzyme systems peculiar

to photosynthesis. The material was extremely sensitive to manipulation and could be used only for short-duration experiments. Whether the further improvement of this technique will lead to the attainment of the biochemical objectives of research in photosynthesis remains to be seen.

Photolysis of Water by Chloroplasts

The first fruitful step toward the realization of the modern biochemical objective of reconstructing photosynthetic events outside the living cell was taken by Hill in 1937 (*33*). In his 1937 paper and subsequent papers (*34, 35*), Hill demonstrated that the evolution of oxygen by isolated chloroplasts under the influence of light—first observed by Engelmann in 1881—could be measured quantitatively by reliable biochemical techniques in accordance with the general equation:

$$A + H_2O \xrightarrow[\text{chloroplasts}]{\text{light}} H_2A + 1/2O_2 \quad (1)$$

in which A represents a hydrogen acceptor other than CO_2. When a suitable hydrogen acceptor was supplied, a stoichiometric amount of molecular oxygen was evolved.

This reaction fell short of being complete photosynthesis because CO_2 could not serve as the hydrogen acceptor A. Hill concluded that chloroplasts contain "a mechanism, the activity of which can be measured apart from the living cell, which under illumination simultaneously evolves oxygen and reduces some unknown substance that is not carbon dioxide" (*34*).

The most useful hydrogen acceptors were substances usually considered foreign to the metabolism of the cell. Among these, benzoquinone (*36*) and ferricyanide (*37*) have been found particularly useful for what Hill designated as "the chloroplast reaction" (*33*), but others have appropriately called it the *Hill reaction*.

Hill's conclusion that isolated chloroplasts, unaided by other enzyme systems, were incapable of reducing CO_2 was confirmed later with the sensitive $C^{14}O_2$ tracer technique by Brown and Franck (*38*) and by Aronoff in Calvin's laboratory (*39*). Later experiments by Vishniac and Ochoa (*40–42*), Tolmach (*43*), and Arnon and Heimbürger (*44, 45*) have also substantiated this conclusion. It thus became a currently established concept that the Hill reaction is "photosynthesis with a substitute oxidant"—that is, photosynthesis without CO_2 fixation (*35, 46*). The chloroplast, in this view, was a "system much simpler than that required for photosynthesis" and was the site of only "the light-absorbing and water-splitting reactions of the over-all photosynthetic process" (*47*).

Reports of CO_2 fixation by isolated chloroplasts came from the laboratory of Boichenko (*48*), but they lacked sufficient experimental details to permit a critical evaluation. The earlier work from that laboratory on photosynthetic CO_2 fixation by cell-free preparations and other Russian work was reviewed by Rabinowitch (*46, 49*).

Pyridine Nucleotide Bridge

The abandonment of the classical concept that chloroplasts are the sites of the complete process of photosynthesis intensified the search for a link between the photolysis of water, now shown to be localized in the chloroplasts, and the CO_2 fixation reactions. A step forward was the finding that, under proper conditions, illuminated, isolated chloroplasts can reduce the well-known physiological electron carriers triphosphopyridine nucleotide (TPN) and diphosphopyridine nucleotide (DPN) (*40, 43, 44*). This permitted the linking of the Hill reaction to many enzymatic reactions, including carboxylations, that are dependent on reduced pyridine nucleotides. Indeed, the expectation that any enzyme system that uses reduced tri- or diphosphopyridine nucleotide can do so whether the reduced coenzymes are produced by respiration or by illuminated chloroplasts was amply documented, particularly by the work of Vishniac and Ochoa (*41*).

The energetically difficult reaction in carbohydrate formation during photosynthesis is the reduction of a carboxyl to a carbonyl group (*46*). The reducing potential of pyridine nucleotides is insufficient to accomplish this step without a lowering of the potential barrier, as by phosphorylation of the carboxyl group by adenosine triphosphate (ATP) (*50*). A workable scheme for photosynthesis should therefore provide for the conversion of light into high-energy chemical bonds, for example, the pyrophosphate bonds of ATP. There are two approaches to this problem. One envisages photosynthesis as a special process involving a direct conversion of light into the chemical-bond energy of ATP or some other energy-rich compound by mechanisms peculiar to green cells. The other regards photosynthesis as a process that, except for the initial photochemical reactions localized in chloroplasts, is in essence a reversal of respiration (*42, 51*). In the latter view, both phosphorylation and carbohydrate formation during photosynthesis would proceed by the same mechanisms and with the aid of the same enzymes that govern cellular metabolism in the dark.

Until now there has been scant experimental evidence for a *sui generis* photosynthetic mechanism of phosphorylation. It is not surprising, therefore, that the mechanisms invoked to explain phosphorylations in the light were modeled on those known to operate in nongreen cells. The high-energy pyrophosphate bonds of ATP are generated in nongreen cells by esterification of inorganic phosphate coupled with oxidation of a variety of substrates. Two pathways are recognized in this process: (i) substrate phosphorylation, essentially independent of oxygen, exemplified by the oxidation of glyceraldehyde-3-phosphate to 1,3-diphosphoglycerate; and (ii) oxidative phosphorylation in which molecular oxygen is the ultimate electron acceptor. The former is characteristic of fermentations, whereas the latter typifies the principal aerobic pathway in respiration, which is linked with the tricarboxylic acid cycle, and accounts for the conversion of 65 to 80 percent of the total energy content of the substrate into the pyrophosphate bonds of ATP (*52*). In aerobic phosphorylation, the electron transport chain is the same, regardless of the substrate that is being oxidized (*52, 53*). The substrate reduces DPN or TPN, and the reduced pyridine nucleotides (PN_{red}) are reoxidized by flavoproteins, cytochromes, and molecular oxygen. This is represented by the following scheme (the arrows indicate the direction of the flow of electrons):

$$PN_{red} \longrightarrow \text{flavoproteins} \longrightarrow \text{cytochromes} \longrightarrow O_2$$

The enzymes responsible for aerobic phosphorylation are not distributed at random in the cell but are localized in mitochondria. The coupling of phosphorylation with the oxidation of reduced pyridine nucleotides by molecular oxygen was demonstrated experimentally by Lehninger (*54*). The over-all reaction, in which he used mitochondria from animal sources, is represented by Eq. 2. (The analogous reaction with TPNH has not, as yet, been experimentally demonstrated.)

$$DPNH + H^+ + 1/2O_2 + 3ADP + 3Pi \xrightarrow[\text{mitochondria}]{} DPN^+ + H_2O + 3ATP \quad (2)$$

where Pi represents inorganic phosphate.

Since illuminated chloroplasts had already been found to be capable of reducing pyridine nucleotides coupled

with carboxylating enzymes, it was only a step further to attempt a linkage between chloroplasts and the mitochondria in the Lehninger reaction. This was accomplished by Vishniac and Ochoa (*55*), who have shown that in a chloroplast-mitochondria system DPN, reduced by the chloroplasts in light, can be reoxidized by molecular oxygen with the aid of enzymes contained in the mitochondria. Vishniac and Ochoa (*55*) concluded from their experiments with the chloroplast-mitochondria system "that the generation of phosphate bonds in photosynthesis may occur through the oxidation by molecular oxygen of photochemically reduced nucleotides." The role of chloroplasts was limited, in this view, to the photochemical transfer of hydrogen from water to coenzymes, most probably DPN and TPN (*42, 55*). Once this was accomplished, all other reactions in photosynthesis would proceed by the same mechanisms as were operative in non-photosynthesizing cells.

Photosynthetic Phosphorylation

It soon became evident that this new scheme of photosynthesis fell short of explaining certain aspects of the process *in vivo*. I can perhaps best illustrate this part of the story by following the sequence of experiments in our laboratory. When we started our work in photosynthesis about 6 years ago, we selected as our objective the reconstruction of a complete extracellular photosynthetic system using only enzyme components from green tissues. This limitation was self-imposed in the belief that it offered at least a partial safeguard against the construction of a model system which, although functional, did not mirror the photosynthetic events in the intact cell.

We began by examining several conflicting observations which at that time cast doubt on the identity of the oxygen-liberating mechanism in isolated chloroplast fragments with the mechanism in intact green cells (*56*). Our results supported the conclusion that the two were the same. Next, in attempting to link oxygen evolution by chloroplasts to CO_2 fixation, we found the TPN-dependent "malic enzyme" in the cytoplasmic fluid of the same leaves from which we isolated the chloroplasts (*44, 45*). This added plausibility to the view that photosynthesis involves an interaction between initial photochemical events, localized in chloroplasts, and subsequent dark reactions catalyzed by enzyme systems outside the chloroplasts. However, we soon had to abandon this hypothesis because of discordant conclusions reached from parallel experiments on the dark reactions of chloroplasts.

We set out to measure the respiration of isolated chloroplast fragments in the dark. We observed an oxygen uptake and CO_2 evolution which we thought at first (*57*) to be endogenous respiration. Subsequent experiments, however, have shown that this gas exchange was an oxidative decarboxylation of oxalate (*58*) by an enzyme contained not in whole chloroplasts but in smaller, non-chloroplast particles that are associated with the "chloroplast fragments" fraction (*59*). The endogenous respiration of chloroplasts was found to be very low. Our results have also suggested that it was unlikely (*59*) that green leaves contained enough of other cytoplasmic particles, such as mitochondria, for the generation of ATP in *photosynthesis*, by the oxidative phosphorylation reaction (Eq. 2) of the chloroplast-mitochondria system (*55*).

We then proceeded to reexamine the question of ATP synthesis by illuminated chloroplasts. Here we encountered a number of surprises. First, we learned that the method of isolating chloroplasts was of far greater importance than we had suspected. Although we had used whole chloroplasts on occasion (*59*), we preferred to work, as a rule, with chloroplast fragments (*56*). Since both preparations were equally active photochemically (*3*), as measured by the quinone reduction test, it was an obvious advantage from a biochemical point of view to use the structurally less complex chloroplast fragments.

In light, isolated whole chloroplasts, unlike chloroplast fragments, vigorously synthesized ATP (*4*) from inorganic phosphate and adenosine mono- or diphosphate (AMP or ADP) (Fig. 1). Whereas, without added mitochondria, the chloroplast-mitochondria system was inactive (*55, 60*), the addition to our chloroplast system of all the other cytoplasmic particles from the leaf gave no increase in phosphorylation (*4*). ATP synthesis in light by whole chloroplasts (the chloroplast system) was not enhanced by the addition of DPN or TPN (*3, 4*); in the chloroplast-mitochondria system the omission of the pyridine nucleotide halved the phosphorylation (*55*).

Phosphorylation by the chloroplast system may thus be distinguished from that by the chloroplast-mitochondria system by its coenzyme requirements and its independence from external enzymes. The most unexpected finding, however, was that phosphorylation by whole chloroplasts was an anaerobic process (*6*). A salient feature of oxidative phosphorylation by mitochondria, which is the basis of aerobic respiration, is molecular oxygen consumption (*52*). "The strict dependence of phosphate exchange on the presence of oxygen" (*55*) was also observed by Vishniac and Ochoa in their model system of illuminated chloroplasts linked to mitochondria of plant or animal origin.

In our early experiments on ATP synthesis by chloroplasts (*3, 4*), oxygen was neither consumed nor evolved. These observations led us to a tentative formulation of the over-all mechanism of phosphorylation by chloroplasts as involving a recombination of an oxidized and a reduced product of water photolysis without the evolution of molecular oxygen (*3, 4*). There remained, however, the discordant observation that a sustained rate of phosphorylation was obtained only under aerobic conditions (*3, 4*). Further investigation then led to the identification of some of the cofactors of chloroplast phosphorylation (*6*). When these were added and conditions were so arranged that traces of oxygen originally present or possibly formed during the reaction were eliminated (shaking in a nitrogen atmosphere in the presence of chromous chloride), phosphorylation proceeded at rates substantially greater than those observed aerobically (*61*). We have concluded, therefore, that ATP synthesis by chloroplasts represents a direct anaerobic synthesis of pyrophosphate bonds at the expense of light energy by a mechanism peculiar to photosynthesis. We have

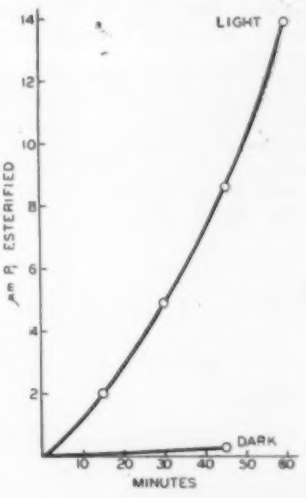

Fig. 1. Photosynthetic phosphorylation, the light-dependent esterification of inorganic phosphate by spinach chloroplasts under strictly anaerobic conditions (*6*). No evolution even of traces of molecular oxygen during the progress of the reaction was detected by the sensitive luminous bacteria method (*24*).

named this light-dependent ATP synthesis by chloroplasts *photosynthetic phosphorylation* to distinguish it from the oxidative phosphorylation by mitochondria in the dark. The over-all reactions in photosynthetic phosphorylation are represented by Eqs. 3, 4, and 5.

$$h\nu + H_2O \xrightarrow{\text{chloroplasts}} 2[H] + [O] \quad (3)$$

$$AMP + 2Pi + 2[H] + [O] \xrightarrow{\text{chloroplasts}} H_2O + ATP \quad (4)$$

Sum:

$$h\nu + AMP + 2Pi \xrightarrow{\text{chloroplasts}} ATP \quad (5)$$

The oxygen and hydrogen atoms in brackets represent an oxidized and a reduced product of the photodecomposition of water (*not* molecular oxygen or hydrogen).

Equation 4 differs from the parallel Eq. 2 of oxidative phosphorylation as carried out by the chloroplast-mitochondria system in that DPN does not appear as a hydrogen carrier and no molecular oxygen is involved. Although certain individual steps in the electron transfer during photosynthetic phosphorylation may be similar to those in oxidative phosphorylation, the two systems seem to represent distinctive structural and functional adaptations to two types of metabolism in green plants: (i) the chloroplast system for the direct conversion of light into chemical energy during photosynthesis, and (ii) the mitochondrial system (*62*) for the interconversions of chemical energy during respiration.

Some of our recent experiments (*7*) support the conclusion that photosynthetic phosphorylation is different from oxidative phosphorylation. Whole chloroplasts that carried out vigorous photosynthetic phosphorylation were unable to oxidize tricarboxylic acid cycle substrates either in light or in dark. On the other hand, smaller cytoplasmic particles (mitochondria?) that were isolated from the same leaves as the whole chloroplasts exhibited oxidative phosphorylation, but not photosynthetic phosphorylation, in a citrate medium.

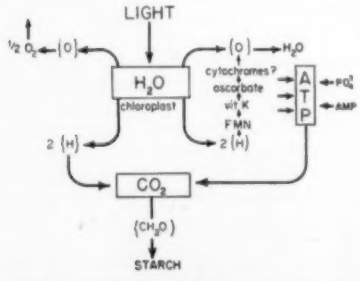

Fig. 2. Scheme for photosynthesis by isolated chloroplasts. Photolysis of water (center) leading either to ATP synthesis and the reconstitution of water (right) or to CO_2 reduction (below) linked to oxygen evolution (left).

As is shown later, whole chloroplasts fix CO_2 in light. It became important, therefore, to determine whether photosynthetic phosphorylation proceeded at the expense of energy released by the reoxidation of partly or wholly reduced products of photosynthetic CO_2 fixation (*63*). We have found that, under both aerobic (*4*) and anaerobic conditions (*7*), photosynthetic phosphorylation is independent of CO_2 fixation. Photosynthetic phosphorylation proceeded unimpaired when CO_2 was excluded from the reaction vessels.

A 1-Quantum Process

Since the energy content of 1 quantum of red light is about 44 kcal (per Einstein) and that of a pyrophosphate bond of ATP 12 kcal (*52*), it is evident that photosynthetic phosphorylation, to be highly efficient, must convert the energy of 1 quantum of light into the energy of two or more pyrophosphate bonds. This could be accomplished if the recombination of the products of water photolysis, [H] and [O], occurred not in one but in several successive steps, each step transforming a portion of the electron energy into phosphate bond energy, in a manner analogous to that envisaged for respiration by Lipmann (*64*).

The reconstruction of an "electron ladder" in photosynthetic phosphorylation depends on the identification of the participating cofactors. Among these the following have been identified so far: Mg^{++}, flavin mononucleotide (FMN), vitamin K, and ascorbate (*6*). The Mg^{++} probably has a catalytic function in the transfer of phosphate groups (*65*). The other cofactors can serve as electron carriers. The quantities in which they are required indicate that these substances act as catalysts and not as substrates (*6*). The identity of the electron carriers above ascorbate is unknown, but they may very likely prove to be components of a cytochrome system (*66*).

A tentative scheme for the "electron ladder" in photosynthetic phosphorylation, based on evidence now available, is shown in Fig. 2. The relative positions assigned to FMN and vitamin K are provisional; they are based solely on published values of redox potentials (*67*). It is possible that, *in vivo*, their positions are reversed, with vitamin K as the primary electron acceptor. Wessels (*68*) has recently postulated, on theoretical grounds, such a role for vitamin K in photosynthesis.

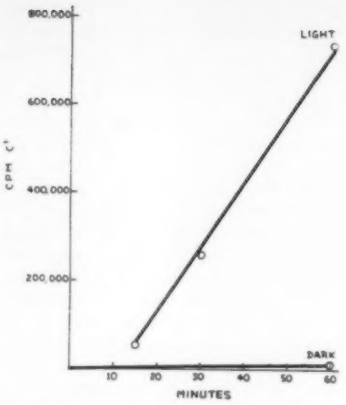

Fig. 3. Time course of CO_2 fixation by isolated spinach chloroplasts in light and in dark. The lag in CO_2 fixation during the first few minutes of illumination is attributed to a time lag in equilibration after the release of $C^{14}O_2$ gas from the sidearm of the reaction vessel (*5*).

An interesting consequence of the proposed scheme for photosynthetic phosphorylation (Fig. 2) is that with either FMN or vitamin K as the primary electron acceptor, the photolysis of water could be accomplished by 1 quantum of red light (44 kcal). In this case, photosynthetic phosphorylation would conform to the Einstein law of photochemical equivalence, which states that in a primary photochemical process each molecule is activated by the absorption of 1 quantum of radiation.

Computations based on known redox potentials (*67*) suggest that, if photosynthetic phosphorylation is a 1-quantum process, either FMN or vitamin K rather than pyridine nucleotide is the primary electron acceptor. Assuming an oxidation level of [O] equal to that of molecular oxygen at 0.2 atm, enough energy would be available in 1 quantum of red light to maintain the ratio of FMN_{red}/FMN_{ox} at approximately 5 at *p*H 7; the comparable ratio for vitamin $K_{1\,red}$/vitamin $K_{1\,ox}$ would be approximately 1000. By contrast, the comparable ratio for DPN_{red}/DPN_{ox} would be approximately 0.00001.

The study of photosynthetic phosphorylation seems to me to offer a new and promising approach to the problem of conversion of light energy into chemical energy during photosynthesis.

Carbon Dioxide Fixation

Isolated whole chloroplasts were found, on exposure to light, to fix CO_2 (Fig. 3) with a simultaneous evolution

Table 1. Carbon dioxide fixation and oxygen production by isolated chloroplasts (*5*).

Expt.	$C^{14}O_2$ fixed (μM)	O_2 produced (μM)
979	1.0	1.5
1010	0.81	0.83
1011	0.38	0.50
1050	1.04	1.0

of oxygen (*5*). The reaction was strictly light-dependent and proceeded at an almost constant rate for at least 1 hr (Fig. 3). There was approximate correspondence between the oxygen evolved and the CO_2 fixed, in agreement with the well-known photosynthetic quotient of 1 (Table 1). Both soluble and insoluble products resulted from the fixation of radiocarbon by chloroplasts. The insoluble product has been identified as starch, which appeared to be the only insoluble compound formed (*5*). The identification of the soluble products of CO_2 fixation is not complete. A typical autoradiogram of the compounds found in the soluble fraction is shown in Fig. 4. Among the compounds so far identified are (i) phosphate esters of fructose, glucose, ribulose, and dihydroxyacetone; (ii) glycolic, malic, and aspartic acids; (iii) alanine, glycine, and free dihydroxyacetone (*5*).

The light-dependent reduction of CO_2 to the level of carbohydrates with a simultaneous evolution of oxygen suggests that whole chloroplasts possess all the enzymes needed for complete photosynthesis.

Specialized Photosynthetic Unit

In the light of our present evidence, chloroplasts emerge as remarkably complete cytoplasmic structures, which contain multienzyme systems divided into three main groups, each controlling an increasingly complex phase of photosynthesis: photolysis of water, photosynthetic phosphorylation, and CO_2 fixation. The suggested interrelationships among the three are shown in Fig. 2.

In vivo, photolysis is linked either with phosphorylation, resulting in the production of ATP and the reconstitution of water, or with CO_2 fixation, resulting in the evolution of oxygen and the reduction of CO_2. Carbon dioxide reduction required the participation of all three groups of enzymes, and phosphorylation required two, whereas photolysis of water can proceed without the others, provided that an artificial hydrogen acceptor is supplied. The last process is, of course, the Hill reaction, which has already been discussed.

The experimental separation of the three phases of photosynthesis is readily accomplished with isolated chloroplasts, either by variations in preparative technique or with the use of inhibitors. In our early experiments (*3*), we reported that the intact structure of whole chloroplasts was essential for both photosynthetic phosphorylation and CO_2 fixation. This is no longer true for photosynthetic phosphorylation (*7*). Chloroplasts can now be prepared that retain a capacity for photolysis alone, or for both photolysis and phosphorylation, or for all three reactions. This interpretation requires, as is experimentally verified, that chloroplasts capable of carrying out a subsequent phase of the process should also be able to carry out the one that precedes it (*3*).

In parallel experiments (*3, 7*) starting with chloroplasts capable of accomplishing complete photosynthesis, it was possible to inhibit a more advanced phase of the process without affecting the simpler one that precedes it. Thus iodoacetamide (*3*) inhibited CO_2 fixation but not photosynthetic phosphorylation or the Hill reaction. Methylene blue ($10^{-5}M$) inhibited both CO_2 fixation and photosynthetic phosphorylation but not the Hill reaction (*7*). On the other hand, as would be expected, *o*-phenanthroline, which inhibits the photolysis reaction (*36, 56*), also inhibited photosynthetic phosphorylation and CO_2 fixation.

There is good reason to believe that the separation of the chloroplast as the "photosynthetic unit" will prove to be a fruitful approach to the study of the detailed mechanism of photosynthesis. I do not suggest that we are ready yet to equate without reservation photosynthesis by isolated chloroplasts with photosynthesis in intact cells. It seems best now to explore the characteristics of extracellular photosynthesis as a separate process and to test later their validity for photosynthesis in whole cells. The most interesting properties of extracellular photosynthesis found so far are (i) total independence of photosynthesis from respiration or from any other process that requires the consumption of molecular oxygen and (ii) direct conversion of light energy into phosphate bond energy by an anaerobic process. Among the unsolved problems of extracellular photosynthesis that are now under consideration are the nature of the reductant in CO_2 fixation, the path of carbon in the formation of sugars and starch, the identity of other cofactors, and the quantum efficiency in photosynthetic phosphorylation.

It is sometimes suggested that extracellular photosynthesis by isolated chloroplasts represents merely a transfer of the process from the familiar environment of the cell to the unfamiliar environment of the test tube with a loss of most of its activity. This argument, if it is not to be taken as sterile neovitalism, could also be applied to respiration. Half a century after Büchner's memorable experiments (*17*) it is still impossible to prevent the loss of 80 to 90 percent of respiration on disrupting yeast cells (*52*). Yet the impressive advances in the understanding of the mechanism of respiration made during this period

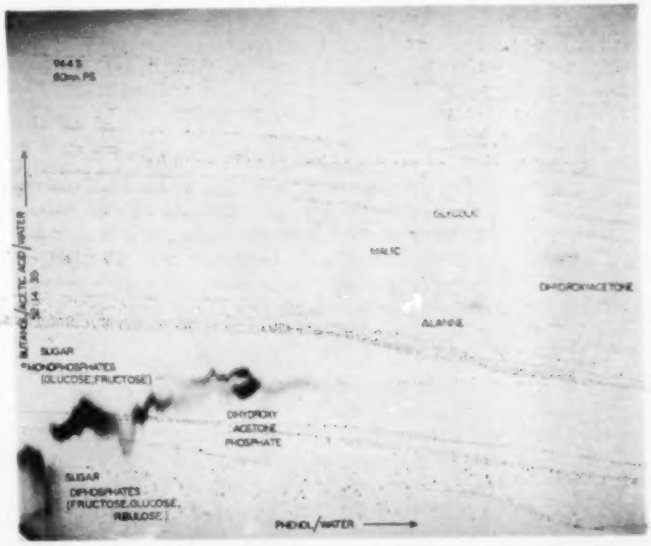

Fig. 4. Typical autoradiograph of the soluble products of CO_2 fixation by isolated chloroplasts. Further details are given elsewhere (*5*).

would have been impossible without dispensing with the complexity of the whole cell. A more optimistic philosophy for present-day approaches to the reconstruction of metabolic sequences outside the cell is aptly expressed by Green (*69*): "The disintegration of the cell is usually attended by the liberation of many destructive enzymes which degrade coenzymes and interfere with or nullify the action of those enzymes whose activity is essential for the metabolic sequence. Thus, even a residual trace of activity is encouraging because there are many ways and means eventually of muzzling the destructive agents and of restoring cofactors which are not present at the levels for maximal activity. . . . Once an *in vitro* system can be found in which a metabolic sequence can be shown to proceed, at least one can be certain that all components needed are present in that system, and by the stepwise simplification and analysis of the system, it is only a question of time, patience, and ingenuity before the entire process is fully reconstructed."

References and Notes

1. Paper was first presented at the symposium, *The Cell*, 29 Dec. 1954, Berkeley, Calif. This research was aided by grants from the National Institutes of Health and the Office of Naval Research.
2. E. I. Rabinowitch, *Photosynthesis* (Interscience, New York, 1945), vol. 1.
3. D. I. Arnon, M. B. Allen, F. R. Whatley, *Proc. 8th Intern. Botan. Congr. Paris* (1954), sect. 11, p. 1; *Nature* **174**, 394 (1954).
4. D. I. Arnon, F. R. Whatley, M. B. Allen, *J. Am. Chem. Soc.* **76**, 6324 (1954).
5. M. B. Allen *et al.*, *ibid.*, in press.
6. F. R. Whatley, M. B. Allen, D. I. Arnon, *Biochem. et Biophys. Acta* **16**, 605 (1955); D. I. Arnon, F. R. Whatley, M. B. Allen, *ibid.* **16**, 607 (1955).
7. D. I. Arnon, M. B. Allen, F. R. Whatley, unpublished data.
8. J. Sachs, *Handbuch der Experimental-Physiologie der Pflanzen* (Engelmann, Leipzig, 1865), p. 319.
9. T. de Saussure, *Recherches chimiques sur la vegetation* (Nyon, Paris, 1804).
10. J. Sachs, *Lectures on the physiology of plants* (Clarendon, Oxford, 1887), p. 290.
11. T. W. Engelmann, *Botan. Zeitung* **39**, 446 (1881).
12. ———, *Pflügers Arch. ges. Physiol.* **57**, 374 (1894).
13. G. F. J. Haberlandt, *Funktion und Lage des Zellkernes* (Fischer, Jena, 1887), p. 118.
14. A. J. Ewart, *J. Linnaean Soc. London, Botany* **31**, 364 (1896).
15. W. Pfeffer, *The Physiology of Plants* (Clarendon, Oxford 1900), vol. 1, pp. 304, 306.
16. L. Pasteur, *Mem. soc. sci. agr. arts, Lille*, 5, 13 (1857).
17. E. Büchner, *Ber. deut. chem. Ges.* **30**, 117, 1110 (1897).
18. R. O. Herzog, *Z. physiol. Chem.* **35**, 459 (1902).
19. J. Friedel, *Compt. rend. acad. sci. (Paris)* **132**, 1132 (1901).
20. ———, *ibid.* **133**, 840 (1901).
21. C. Bernard, *Botan. Centr. Beih.* **A16**, 36 (1904).
22. M. Harroy, *Compt. rend. acad. sci. (Paris)* **133**, 890 (1901).
23. L. Macchiati, *ibid.* **135**, 1125 (1902).
24. M. W. Beijerinck, *Koninkl. Akad. Wetenschap. Amsterdam* **4**, 45 (1901).
25. H. Molisch, *Botan. Zeitung* **62**, 1 (1904).
26. ———, *Z. Botan.* **17**, 578 (1925).
27. O. L. Inman, *Cold Spring Harbor Symposia Quant. Biol.* **3**, 184 (1935).
28. C. B. van Niel, *Arch. Mikrobiol.* **3**, 1 (1931).
29. F. C. Gerretsen, *Nature* **171**, 207 (1953).
30. E. W. Fager, *Arch. Biochem. and Biophys.* **37**, 5 (952).
31. ———, *ibid.* **41**, 383 (1952).
32. N. E. Tolbert and L. P. Zill, *J. Gen. Physiol.* **37**, 575 (1954).
33. R. Hill, *Nature* **139**, 881 (1937).
34. ———, *Proc. Roy. Soc. London* **B127**, 192 (1939).
35. ———, *Symposia Soc. Exptl. Biol.* **5**, 223 (1951); *Advances in Enzymol.* **12**, 1 (1951).
36. O. Warburg and W. Lüttgens, *Biokhimya* **11**, 303 (1946).
37. A. S. Holt and C. S. French, *Arch. Biochem.* **9**, 25 (1946).
38. A. H. Brown and J. Franck, *ibid.* **16**, 55 (1948).
39. S. Aronoff, cited by A. A. Benson and M. Calvin, *Ann. Rev. Plant Physiol.* **1**, 25 (1950).
40. W. Vishniac and S. Ochoa, *Nature* **167**, 768 (1951).
41. ———, *J. Biol. Chem.* **195**, 73 (1952).
42. S. Ochoa and W. Vishniac, *Science* **115**, 297 (1952); *Phosphorus Metabolism II*, W. D. McElroy and B. Glass, Eds. (Johns Hopkins Univ. Press, Baltimore, 1952).
43. L. J. Tolmach, *Nature* **167**, 946 (1951); *Arch. Biochem. and Biophys.* **33**, 120 (1951).
44. D. I. Arnon, *Nature* **167**, 1008 (1951).
45. D. I. Arnon and G. Heimbürger, *Plant Physiol.* **27**, 828 (1952).
46. E. Rabinowitch, *Ann. Rev. Plant Physiol.* **3**, 229 (1952).
47. R. Lumry, J. D. Spikes, H. Eyring, *ibid.* **5**, 271 (1954).
48. A. P. Vinogradov, E. A. Boichenko, V. I. Baranov, *Doklady Akad. Nauk. S.S.S.R.* **78**, 327 (1951); *Chem. Abstr.* **45**, 10310 (1951); E. A. Boichenko and V. I. Baranov, *Doklady Akad. Nauk. S.S.S.R.* **91**, 339 (1953); *Chem. Abstr.* **47**, 11360 (1953); *Doklady Akad. Nauk. S.S.S.R.* **95**, 1025 (1954); *Chem. Abstr.* **48**, 8881 (1954).
49. E. I. Rabinowitch, *Photosynthesis and Related Processes* (Interscience, New York, 1951), vol. 2, pt. 1, p. 873.
50. F. Lipmann, *Advances in Enzymol.* **1**, 99 (1941).
51. K. V. Thimann, *Science* **88**, 506 (1938); S. Ochoa, in *Currents in Biochemical Research*, D. E. Green, Ed. (Interscience, New York, 1946), p. 165; M. Calvin and P. Massini, *Experientia* **8**, 445 (1952).
52. H. A. Krebs, in *Chemical Pathways of Metabolism*, D. M. Greenberg, Ed. (Academic Press, New York, 1954), vol. 1, p. 109.
53. E. G. Ball, in *Symposium on Respiratory Enzymes* (Univ. of Wisconsin Press, Madison, 1942), p. 16.
54. A. L. Lehninger, *J. Biol. Chem.* **190**, 345 (1951).
55. W. Vishniac and S. Ochoa, *ibid.* **198**, 501 (1952).
56. D. I. Arnon and F. R. Whatley, *Arch. Biochem.* **23**, 141 (1949).
57. D. I. Arnon, *Am. J. Botany* **47**, 675 (1950); *Proc. 7th Intern. Botan. Congr. Stockholm* (1950), p. 749.
58. B. J. Finkle and D. I. Arnon, *Physiol. Plantarum* **7**, 614 (1954).
59. D. I. Arnon and F. R. Whatley, *ibid.* **7**, 602 (1954).
60. In a recent personal communication, W. Vishniac has reported that in later experiments with whole chloroplasts he also observed esterification of inorganic phosphate that took place without the addition of mitochondria.
61. A. Frenkel, *J. Am. Chem. Soc.* **76**, 5568 (1954).
62. A. Millerd *et al.*, *Proc. Natl. Acad. Sci. (U.S.)* **37**, 855 (1951).
63. J. Franck, *Arch. Biochem. and Biophys.* **45**, 190 (1953).
64. F. Lipmann, in *Currents in Biochemical Research*, D. E. Green, Ed. (Interscience, New York, 1946), p. 145.
65. W. D. McElroy and A. Nason, *Ann. Rev. Plant Physiol.* **5**, 1 (1954).
66. H. E. Davenport and R. Hill, *Proc. Roy. Soc. London* **B139**, 137 (1952); H. Lundegårdh, *Physiol. Plantarum* **7**, 375 (1954); L. N. M. Duysens, *Nature* **173**, 692 (1954).
67. L. Anderson and G. W. E. Plaut, in *Respiratory Enzymes*, H. A. Lardy, Ed. (Burgess, Minneapolis, 1949).
68. J. S. C. Wessels, *Rec. trav. chim.* **73**, 529 (1954).
69. D. E. Green, in *Chemical Pathways of Metabolism*, D. M. Greenberg, Ed. (Academic Press, New York, 1954), vol. 1.

I cannot express the amazed awe, the crushed humility, with which I sometimes watch a locomotive take its breath at a railway station, and think what work there is in its bars and wheels, and what manner of men they must be who dig brown iron-stone out of the ground and forge it into that. What assemblage of accurate and mighty faculties in them, more than fleshly power over melting crag and coiling fire, fettered and finessed at last into the precision of watchmaking; Titanian hammer-strokes beating out those glittering cylinders and timely respondent valves, and fine ribbed rods, which touch each other as a serpent writhes in noiseless gliding and omnipotence of grasp, an infinite complex anatomy of active steel. What would the men who beat this out, who touched it with its polished calm of power, who set it to its appointed task and triumphantly saw it fulfill the task to the utmost of their will, feel or think about this weak hand of mine timidly leading a little stain of water color which I cannot manage into the imperfect shadow of something else . . . what, I repeat, would these iron-dominant genii think of me, and what ought I to think of them?—JOHN RUSKIN.

Early History of the Scintillation Counter

A. T. Krebs

One of the most impressive events in modern physics is the development of the scintillation counter. At first a very simple device, this instrument has become one of the most powerful tools in all fields in which ionizing radiations are encountered. Considering its still-growing importance, it appears justified and desirable to sketch in a brief essay the early history of the instrument.

The modern scintillation counter has its origin in the classical scintillation method that was used so extensively in the early years of radiation research by the English School under Rutherford (*1*), and by the Vienna School under Meyer, Schweidler, and others (*2*). This method, in which the scintillations were observed subjectively with a microscope, led to important discoveries. The last of these great discoveries was the first man-made disintegration of an element with artificially accelerated particles, the disintegration of lithium with accelerated protons by Cockcroft and Walton (*3*) in 1932.

At about this time the Geiger-Mueller counter had definitely proved to be one of the most advantageous instruments for nuclear research, and its outstanding ability to detect and count objectively thousands of elementary nuclear events per unit of time made it the instrument of choice for future nuclear research. Therefore the subjective, tiresome, and difficult scintillation method was shelved and was demonstrated merely from time to time to students and/or in lectures as an interesting historical device.

The first attempt to bring the scintillation method back into nuclear research in an improved form was made in 1940–41. At this time a device was developed in which, instead of the eye, a highly sensitive, fast-responding, photoelectric device was used for the detection and counting of scintillations.

A second attempt to introduce an improved scintillation method in nuclear research was started in the war year 1944. It was followed by a stormy renaissance of the principle after World War II in the years 1947–50.

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Today, two highly developed types of scintillation counters are available: the photon-tube scintillation counter and the photomultiplier scintillation counter. Both types have advantages and disadvantages, and both methods have been applied with great success in different fields.

Photon-tube counters. Photon tube counters are a combination of the classical scintillation arrangement with a photosensitive Geiger tube of special design. The device developed by Krebs (*4*) in 1940–41 is shown in Fig. 1. It consists of an arrangement in which the scintillation phosphor and the photoelectric detector are separate units.

The choice of photon tubes as scintillation indicators was dictated by the needs of the time (*5*). Photon tubes could easily be self-built and they could be "bred" to a high sensitivity—according to published data up to 12 quanta/cm² sec, equivalent to 9.1×10^{-11} ergs/cm² sec of light with the wavelength, λ, of 2600 A (*6*).

The first self-built photon tubes were relatively insensitive and the geometry of the arrangement was poor, but the first measurements showed that the principle would work. Soon, by taking advantage of earlier experience in building special G-M tubes (*7*), tubes with higher sensitivities could be built and the geometry could be improved so that the efficiency was increased considerably (*8*). With the first simple equipment, the scintillations produced by polonium alpha particles in zinc sulfide could be recorded, and the diffusion of radon and thoron in closed volumes could be measured quantitatively.

The rediscovery of the photon-tube principle by Mandeville and coworkers (*9*) in 1950 stimulated further improvements and resulted in an increased sensitivity of photon-tube scintillation counters. By bringing the scintillation phosphor into close contact with the walls of the photon tube (Fig. 2), Mandeville *et al.* could apply the counter successfully for the detection of alpha, beta, and gamma radiation. Special sensitization of the photon tubes (*10*) and the development of special counter types and amplifier circuits brought the instruments to a still higher degree of perfection (*11*). At present, commercially manufactured scintillation tubes are available that show, according to measurements by Daggs, Parr, and Krebs (*12*), a high area sensitivity and short resolving times.

Photomultiplier-tube counters. The first scintillation counter of this kind, in which the classical method is combined with a photomultiplier for the detection of the scintillations, was built in 1944 by Curran and Baker (*13, 14*) and is shown in Fig. 3.

The original report of Curran and Baker showed theoretically, as well as experimentally, that with proper arrangement of the parts, individual alpha particles with energies of 2×10^6 ev could easily be detected. Using zinc sulfide crystals as a scintillation screen, a photomultiplier tube type 1P21, and proper circuit elements, they calculated that an alpha particle with the afore-mentioned energy should produce in the oscilloscope an average pulse amplitude of 4.75 ev. The *de facto* pulse amplitude measured was 6 ev, a value in close agreement with the figures calculated from rough data. The great advantages of the instrument with regard to sensitivity, resolving time, and ease of handling were emphasized in the first report of Curran and Baker (*13*).

As in the case of the photon-tube scin-

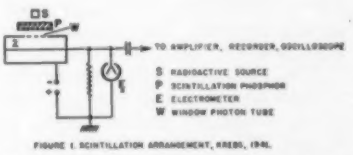

Fig. 1. Scintillation arrangement, Krebs, 1941.

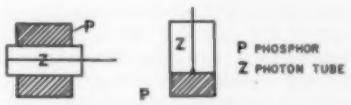

Fig. 2. Photon-tube scintillation counters, Mandeville *et al.*, 1950. (Left) Tube counter; (right) end-window counter.

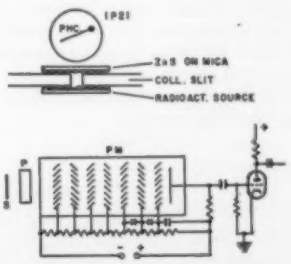

Fig. 3. Scintillation counter, Curran and Baker, 1944. (Top) Geometric arrangement; (bottom) diagrammatic representation.

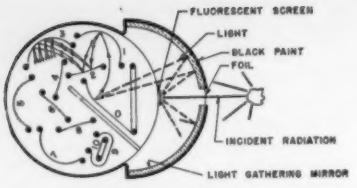

Fig. 4. Scintillation detector, Coltman and Marshall, 1947. Photocathode, 0; dynodes, 1 to 9; anode, 10.

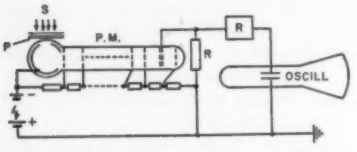

Fig. 5. Scintillation arrangement, Broser and Kallman, 1947. Alpha radiation, *S*; phosphor, *P*; photomultiplier, *P.M.*

tillation counter, the war years prevented a natural development of the photomultiplier scintillation counter and it was not until 1947–48 that the advantages of the instrument were generally recognized. At this time several new publications appeared, the timely sequence of which may be of interest in discussing the early history of the scintillation counter.

Marshall, Coltman, and coworkers, who in March 1947 submitted for publication a report on "The photomultiplier x-ray detector" (*15*), demonstrated on 22 May 1947, at the Mid-American Exposition Atomic Energy Show, a high-speed "atomic ray detector" (*16*). On 17 June 1947, they also presented papers on "The photomultiplier radiation detector" at the Montreal meeting of the American Physical Society (*17*). In these papers, later published in detail, they reported the detection and counting of single alpha particles, beta particles, gamma quanta, high-energy electrons, protons, soft x-rays, and neutrons (*18*). Marshall and Coltman also stated that at least three major improvements of the detector (Fig. 4) could be expected: better scintillators varying with regard to type, thickness, and reflective backing in accordance with the specific radiation involved; improved optical systems; and the development of auxiliary circuits adapted to the special needs of scintillation counting.

Broser and Kallmann (*19*) submitted a paper for publication on 2 May 1947 that described the detection and recording of alpha-particle scintillations in zinc sulfide with the aid of a photomultiplier tube. They used a Weiss-type photomultiplier in connection with an oscilloscope (Fig. 5). The average pulse height produced by the applied alpha particles was equivalent to several hundredths of a volt, and the pulse time was estimated to be somewhat shorter than 10^{-5} sec.

At the time of the reading of the galley proof, Broser and Kallmann added a short footnote saying that individual electrons and gamma quanta could also be recorded with the aid of different scintillators. The detailed report on these studies with ZnS, $CaWO_4$, Zn_2SO_4, naphthalene, and a few other substances was submitted for publication on 27 June 1947 (*20*). The years after 1947 brought decisive publications: a short note by Deutsch (*21*) and review articles by Bell (*22*), Hofstadter (*23*), Morton and Mitchell (*24*), Jordan and Bell (*25*), Mayneord (*26*), Pringle (*27*), and others. These studies stimulated and inaugurated the extensive development that followed. Soon it became generally recognized that the scintillation counter was ". . . one of the most important advances in devices for the detection of nuclear radiations since the invention of the Geiger-Mueller counter in 1926 . . ." (*24*), which ". . . heralded a new era of scientific development and research . . ." (*27*). This area of development and research includes many fields: nuclear physics, cosmic-ray research, medical physics, biophysics, radiobiology, carbon-14 dating, and others.

The ultimate value and importance of the instrument for development and progress in the different fields can only be guessed at present. For the field of nuclear physics, Birks (*28*) has already stated that ". . . the history of the instrument since 1949 is largely a history of experimental nuclear research. . . ." A similar formulation appears to be justified in the other fields where the scintillation counter has brought valuable insights and knowledge to problems concerning the energy-transport and energy-migration mechanisms in irradiated physical, chemical, and biological systems and to problems of the radioactivity of the human being and carbon-14 dating.

References

1. M. Rutherford, J. Chadwick, C. D. Ellis, *Radiations from Radioactive Substances* (Cambridge Univ. Press, Cambridge, 1951).
2. S. Meyer and E. Schweidler, *Radioactivität*) (Teubner, Leipzig, 1927).
3. J. D. Cockcroft and E. F. S. Walton, *Proc. Roy Soc.* (London) A137, 229 (1932).
4. A. Krebs, *Ann. Physik* 39, 330 (1941); *Ergeb. exak. Naturw.* 27, 361 (1953).
5. H. Himmelreich and A. Krebs, unpublished, 1940–41.
6. B. Rajewsky, "Ueber einen empfindlichen Lichtzähler," *Physik Z.* 32, 121 (1931).
7. A. Krebs, "Measurement of radioactive precipitates with special Geiger-Mueller counters," *ibid.* 35, 796 (1934).
8. ———, *Vorträge*, Radiumforschungsinstitut der Kaiser Wilhelm Gesellschaft, Radiumspa Oberschlema, Saxony, 1941–45.
9. C. E. Mandeville and H. O. Albrecht, "Detection of scintillations from crystals with a photosensitive Geiger-Mueller counter," *Phys. Rev.* 79, 1010 (1950); "Detection of beta-induced scintillations from crystals with a photosensitive Geiger-Mueller counter," *ibid.* 80, 117 (1950); "Detection of gamma-induced scintillations from crystals with a photosensitive Geiger-Mueller counter," *ibid.* 81, 164 (1950); "Crystals for the scintillation Geiger counter," *ibid.* 81, 163, (1950); C. E. Mandeville and M. V. Scherb, "Photosensitive Geiger counters: their applications," *Nucleonics* 7, No. 5, 34 (1950).
10. M. V. Scherb, "Photoelectric effect in self-quenching Geiger-Mueller counters," *Phys. Rev.* 73, 86 (1948).
11. W. C. Porter, "Extending the efficiency range of Geiger-Mueller counters," *Nucleonics* 11, No. 3, 33 (1953).
12. V. Daggs, W. Parr, A. Krebs. *Nucleonics* 10, No. 1, 54 (1952).
13. S. C. Curran and W. R. Baker. "A photoelectric alpha particle detector," U.S. Atomic Energy Commission Rpt. MDDC 1296, 17 Nov. 1944.
14. S. C. Curran, *Luminescence and the Scintillation Counter* (Academic Press, New York, 1953).
15. F. H. Marshall, J. W. Coltman, L. P. Hunter. *Rev. Sci. Instr.* 18, 504 (1947).
16. Westinghouse Electric Corp., Central Publicity Div., No. 69524, 22 May 1947.
17. F. H. Marshall and J. W. Coltman, *Phys. Rev.* 72, 528 (1947).
18. J. W. Coltman and F. H. Marshall, *Nucleonics* 1, No. 3, 58 (1947).
19. I. Broser and H. Kallmann, "Ueber die Anregung von Leuchtstoffen durch schnelle Korpuskularteilchen I," *Z. Naturforsch.*, 2a, 439 (1947).
20. ———, "Ueber den Elementarprozess der Lichtanregung in Leuchtstoffen durch Alphateilchen, Schnelle Elektronen und Gammaquanten II," *ibid.* 2a, 642 (1947).
21. M. Deutsch, "Naphthalene counters for beta- and gamma-radiation," *Nucleonics* 2, No. 3, 58 (1948).
22. P. R. Bell "The use of anthracene as a scintillation counter," *Phys. Rev.* 73, 1405 (1948).
23. R. Hofstadter, "Alkali halide scintillation counters," *ibid.* 74, 100 (1948).
24. G. A. Morton and J. A. Mitchell, "Performance of 931-A type multiplier as a scintillation counter," *Nucleonics* 4, No. 1, 6 (1949).
25. W. H. Jordan and P. R. Bell, "Scintillation counters," *ibid.* 5, No. 4, 30 (1949).
26. W. V. Mayneord and E. H. Belcher, "Scintillation counting and its medical applications," *Brit. J. Radiol.* Suppl. 2–3, 259 (1950).
27. R. W. Pringle, *Nature* 166, 11 (1950).
28. J. B. Birks, *Scintillation Counters* (McGraw-Hill, New York, 1953).

They that know the entire course of the development of science will, as a matter of course, judge more freely and more correctly of the significance of any present scientific movement than they, who limited in their views to the age in which their own lives have been spent, contemplate merely the momentary trend that the course of intellectual events takes at the present moment.—ERNST MACH in *Science of Mechanics.*

Tocopherol as an Activator of Cytochrome C Reductase

Alvin Nason and I. R. Lehman

Since its discovery more than 30 years ago as a fat-soluble factor necessary for reproduction in the rat, vitamin E(α-, β-, γ-, and δ-tocopherols) has been associated with a wide variety of biological processes. A number of recent reviews (*1–3*) have summarized the current status of our knowledge of the vitamin. Its chemical nature and synthesis have been established, and its wide distribution among plants and animals is well recognized. Detailed studies have been made of the effects of vitamin-E deficiency in various animals as well as of the effects of its addition *in vivo* and *in vitro* to various tissues and cell-free systems. Nevertheless, its primary mechanism of action in the living organism is still unknown. In addition to its role as an antisterility factor for the laboratory rat, vitamin E has also been shown to be necessary for the structural and functional maintenance of skeletal muscle, cardiac muscle, smooth muscle, and the peripheral vascular system in a number of animals. The muscular dystrophy and morphological alterations in various tissues associated with vitamin-E deficiency are accompanied by an increased oxygen consumption of the dystrophic muscle and by alterations in chemical composition and functional behavior. Many of these effects have been attributed to the action of tocopherol as an intracellular antioxidant, namely, its protective action in inhibiting the oxidation of unsaturated fats and other oxygen-sensitive substances, such as vitamins A and C, during storage. It is generally believed, however, that the nonspecific action of tocopherol as a physiological antioxidant represents a secondary role; and that the vitamin acts primarily and specifically through some enzyme system.

The role of tocopherol as an inhibitor of cytochrome *c* reduction in the metabolism of skeletal muscle has been postulated by Houchin (*4*), who reported an increased rate of succinic acid oxidation by hamster dystrophic muscle (*4, 5*). Basinski and Hummel (*6*) found, however, that under comparable conditions the succinic dehydrogenase system is apparently unaffected. Although general disturbances in phosphorylation mechanisms have been noted in dystrophic muscle, including depression of the creatine level (*5, 7*) and the diminution of adenosine triphosphatase (*8*), no decrease has been observed in oxidative phosphorylation in preparations of heart tissues of dystrophic rabbits (*9*). A decrease has been reported in the choline esterase content of tissues deficient in vitamin E (*10, 11*).

The action of tocopherol and its derivatives, especially the esters, on isolated enzyme systems has received some attention. D-α Tocopheryl phosphate has been especially used for this purpose because of its greater solubility in water and its implied involvement in energy transformations by virtue of its phosphate group. However, it has been shown that the phosphate ester, when it is added *in vitro,* markedly inhibits practically every enzyme on which it has been tested. The inhibition of the succinic oxidase system by D-α-tocopheryl phosphate apparently consists of both a specific action (*12*) and a nonspecific secondary mechanism involving calcium removal (*13*). The latter effect inhibits diphosphopyridine nucleotidase, with the result that the formation of appreciable oxaloacetate (in the DPN-malate system) occurs. (The abbreviation DPN is used to represent diphosphopyridine nucleotide.) This in turn inhibits succinate oxidation (*14*). Some of the other enzymes reported to be inhibited by α-tocopheryl phosphate are trypsin (*15*), liver acid phosphatase (*16*), hyaluronidase (*17*), liver esterase (*11*), and lipoxidase (*18*). Rabinovitz and Boyer (*19*) concluded that the observed effects of α-tocopheryl phosphate on enzyme systems are the result of its properties as an anion with a large nonpolar group and that its effects are not necessarily related to its action as a vitamin.

The hypothesis that tocopherol may possibly be acting as a carrier in biological oxidation-reduction reactions receives support from chemical studies that demonstrate reversible oxidation products of the vitamin (*20, 21*). Boyer (*21*) isolated and tentatively characterized an intermediate, biologically active, reversible oxidation product of D-α-tocopherol prepared by ferric chloride oxidation in the presence of 2,2'-bipyridine. The product, designated as D-α-tocopheroxide, is readily reduced to D-α-tocopherol by ascorbic acid or converted irreversibly to D-α-tocopheryl quinone upon exposure to dilute acid. The latter can be reduced to the corresponding hydroquinone. The tocopherol free radical of Michaelis and Wollman (*20*) is probably an intermediate in the reversible transformation between tocopherol and tocopheroxide.

In the work reported in this article (*22*), the possibility suggested itself that if tocopherol is involved in biological oxidation-reductions, it might conceivably act as a carrier in the oxidation of reduced pyridine nucleotides. In our experiments, it has been possible to demonstrate with purified particulate or solubilized preparations from rat skeletal muscle that tocopherol can specifically function as an activator in the enzymatic reduction of cytochrome *c* by reduced diphosphopyridine nucleotide (DPNH). The reduction of cytochrome *c* by succinate in the presence of a particulate preparation from the same source has also been shown to have a tocopherol requirement.

Preparation of the enzyme and its stimulation by tocopherol. In preliminary studies using a 15- to 25-fold purified particulate fraction from rat skeletal muscle, it has been possible to show a marked enhancing effect of D-α-tocopherol on the rate of DPNH oxidation in air. Fresh muscle was homogenized with phosphate buffer (*p*H 7.5) in a Ten Broeck tissue grinder. The supernatant solution resulting from centrifugation at 2000 *g* was dialyzed for 1 to 3 hr and recentrifuged to remove a heavy gelatinous protein precipitate. Approximately 90 percent of the activity of this supernatant solution was then collected by centrifugation for 30 min at 140,000 *g*; the pellet was suspended in phosphate buffer to yield the final preparation. The addition to this system of D-α-tocopherol or its tocopheroxide as an ethanol-albumin or ethanol-γ-globulin suspension (*23*) stimulated the rate of DPNH oxidation as much as six-fold over a control without tocopherol. The tocopherol effect could be doubled by the addition of cytochrome *c*. This fact, as well as the presence of cytochrome *c* reductase and cytochrome *c* oxidase in the system, shows that these components are on the main pathway of electron transport between DPNH and oxygen in the enzyme preparation. That tocopherol acts at some point between DPNH and cyto-

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chrome *c* was shown by the fact that it stimulated cytochrome *c* reductase activity but not cytochrome *c* oxidase activity.

Isooctane extraction of the enzyme. To demonstrate the tocopherol enhancement effect with each new enzyme preparation it was necessary to store the enzyme fraction at −15°C for 2 to 10 days with occasional testing. The assumption that the enzyme system is accompanied by a tocopherol-like component that partially dissociates under the aforementioned conditions prompted an attempt to remove the presumed "tocopherol cofactor" by extraction with various nonpolar solvents. Figure 1 shows the effect on DPN-cytochrome *c* reductase activity of extracting the enzyme by shaking with isooctane (2,2,4-trimethylpentane). This was by far the most effective of some 25 organic solvents tested. Three to five extractions of the particulate enzyme fraction with isooctane resulted in about a 75-percent decrease in cytochrome *c* reductase activity. The latter could then be completely restored by addition of D-α-tocopherol. Further extractions resulted in a progressive loss of activity that could be only partially reversed by subsequent addition of the vitamin. The oxidation of DPNH exhibited essentially the same behavior as is shown in Table 1; whereas cytochrome *c* oxidase (*24*) showed a progressive loss of activity that could not be restored by subsequent addition of tocopherol. The succinate-cytochrome *c* reductase system from the same source also showed a similar striking tocopherol requirement after isooctane treatment. Experiments that involved combining the unextracted and isooctane-extracted enzymes ruled out the presence of an inhibitor in the latter.

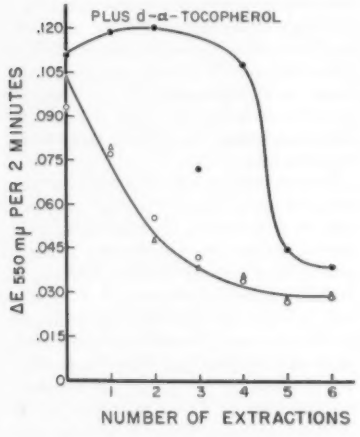


Fig. 1. Effect of isooctane extraction and subsequent reactivation by tocopherol on DPN-cytochrome *c* reductase activity in a particulate fraction from rat skeletal muscle. The reaction mixture contained 0.05 ml of enzyme (185 μg of protein), 0.10 ml of 1-percent aqueous cytochrome *c*, 0.3 ml of $10^{-2}M$ KCN, 0.1 ml of DPNH (6.1 μmole/ml) and $10^{-1}M$ phosphate buffer (*p*H 7.5) to give a final volume of 3.0 ml; 0.03 ml of 15-percent ethanol-2-percent bovine serum albumin, or 0.03 ml of D-α-tocopherol (about 4/μmole/ml) in a 15-percent ethanol-2-percent bovine serum albumin suspension was added to indicated reaction mixtures to give a final volume of 3.0 ml. Control, O——O; Ethanol-albumin added, Δ——Δ; D-α-tocopherol added ●——●. Each isooctane extraction was performed by shaking the enzyme with an equal volume of cold isooctane (2,2,4-trimethylpentane) for 1 min. The isooctane layer was then discarded.

Treatment of the particulate system with an aqueous digitonin solution, followed by centrifugation at 140,000 *g* for 30 min, resulted in a clear supernatant solution containing more than 50 percent of the DPN-cytochrome *c* reductase. This activity could then be decreased to as little as 10 percent by a single isooctane extraction step and then completely restored by the addition of D-α-tocopherol.

Specificity of tocopherol stimulation. Figure 2 summarizes the effects of different concentrations of the various tocopherols and derivatives, as well as other fat-soluble compounds, in restoring the activity of isooctane-extracted DPN-cytochrome *c* reductase (*25*). Although the tocopherols and D-α-tocopheroxide showed some differences in their affinities and saturation levels for the enzyme, they were all quite effective. On the other hand the succinate, acetate, and polyethylene glycol 1000 succinate esters showed little or no effect, as is typified by the data for the disodium salt of D-α-tocopheryl phosphate (Fig. 2). The vitamin-E nucleus (2,2,5,7,8-pentamethyl, 6-hydroxychroman), vitamin D_2, lipoic acid, menadione, cystine, oleic acid, and cholesterol (in final concentrations ranging from 10^{-4} to $10^{-5}M$) showed little or no activity, as is typified by the vitamin K_1 results (Fig. 2). The antioxidants nordihydroguaiaretic acid, santoflex B, propylparasept, dibutyl *p*-cresol, diphenyl *p*-phenylene diamine, and santoquin (*25*) were completely inactive at final concentrations ranging from 10^{-4} to $10^{-5}M$. The latter two compounds have been reported to be effective substitutes for vitamin E in protecting against dietary necrotic liver degeneration (*26*). These results emphasize the specific requirement for the tocopherols by cytochrome *c* reductase. The comparable activities of tocopherylquinone (Fig. 2) and its hydroquinone are of interest, especially in view of their biopotency in the rabbit but not in the rat (*2*). The failure of the tocopheryl esters to act is perhaps indicative of the need for the free hydroxyl or carbonyl group in the 6-position for activity. The activities of the different tocopherols in the cytochrome *c* reductase system show no correlation with their biological potencies as reported in the literature (*1–3*).

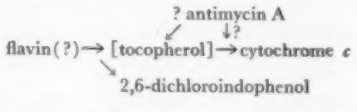
Table 1. Effect of isooctane extraction (enzyme extracted with isooctane as described in Fig. 1) on DPNH oxidase activity in a particulate fraction from rat skeletal muscle and subsequent reactivation by addition of tocopherol. The control reaction mixture contained 0.05 ml of one-fifth-diluted enzyme (43 μg of protein), 0.05 ml of 2-percent aqueous cytochrome *c*, 0.10 ml DPNH (1.15 μmole/ml), and $10^{-1}M$ tris(hydroxymethyl) aminomethane buffer (*p*H 7.9) to give a final volume of 1.0 ml. The albumin mixture contained 0.03 ml of 15-percent ethanol-2-percent bovine serum albumin suspension added to reaction mixtures indicated to give a final volume of 1 ml. The tocopherol mixture contained 0.03 ml D-α-tocopherol (1.1 μmole/ml) in a 15-percent ethanol-2-percent bovine serum albumin suspension added to reaction mixtures indicated to give a final volume of 1.0 ml.

No. of extractions	DPNH oxidase activity ($-\Delta E_{340}$ per 4 min × 10^3)		
	Control	Albumin added	D-α-Tocopherol added
0	121	153	232
1	169	158	239
2	95	73	250
3	49	44	236
4	42	37	199
5	41	36	175
6	18	31	158

In the absence of added tocopherol, complete restoration of enzyme activity has been obtained by adding to the extracted cytochrome *c* reductase the residue remaining after vacuum distillation of the isooctane extract of boiled enzyme. Preliminary examination of such active isooctane-extraction residues has failed to reveal, in almost all cases, the presence of any free tocopherol as measured by a paper-chromatography procedure (*27*) with a demonstrated ability to detect 5 μg. Furthermore, spectrophotometric examination of the residue before and after treatment with ascorbic acid, the latter to reduce any possible tocopheroxide present (*21*), failed to show the absorption in the region of 297 mμ that is characteristic of tocopherol. These results are suggestive of the existence of a lipid cofactor replaceable specifically by tocopherol. However, the possibility still exists that vitamin E is unrelated to such a cofactor.

Antimycin inhibition and indophenol reduction. The striking inhibition of the solubilized, unextracted cytochrome *c* reductase by antimycin A (Fig. 3) is suggestive of a factor between DPN and cytochrome *c* heretofore not reported for a soluble system. At concentrations of antimycin A causing 40 to 70 percent inhibition, partial reversal of the inhibitory effect was obtained by adding D-α-tocopherol but not by adding solutions of crystalline bovine serum albumin or human serum γ-globulin, both of which have served as vehicles for the α-tocopherol. At higher concentrations of antimycin A, no reversal by tocopherol was attained. Further experiments showed a competitive inhibition of antimycin A with tocopherol in the cytochrome *c* reductase system as demonstrated by a Lineweaver-Burk plot (*28*). When 2,6-dichloroindophenol was used as the electron acceptor in place of added cytochrome *c*, there was no inhibition by antimycin A (0.001 to 0.2 μg/ml of reaction mixture) of dye reduction. Extraction with isooctane caused no change, as compared with the unextracted enzyme, in the rate of dye reduction with or without added D-α-tocopherol; whereas the rate of cytochrome *c* reduction was more than 50 percent lower if tocopherol was not added.

In view of these results it appears that in the stepwise reduction of cytochrome *c* by DPNH, mediated by the enzyme system from rat skeletal muscle, vitamin E, perhaps in a conjugated form, is involved as an activator or cofactor according to the following scheme:



Whether tocopherol (or an unknown lipid cofactor) serves in some indirect fashion or undergoes alternate oxidation and reduction during the course of electron transport—possibly to the free radical (*20*) or to the tocopheroxide (*21*)—has not been established. Thus far it has not been possible to show either that D-α-tocopherol will serve as an electron donor in place of DPNH for cytochrome *c* reduction, or that D-α-tocopheroxide will serve as an electron acceptor for DPNH-oxidation in this system. A function of tocopherol or a lipid cofactor in this system in coupling phosphorylation with electron transport between DPNH or succinate and cytochrome *c* may not be unlikely.

By use of the isooctane extraction procedure, it has been possible to demonstrate a D-α-tocopherol stimulation of cytochrome *c* reductases in rat liver, yeast, neurospora, soybean leaves, hamster skeletal muscle, and beef heart fractions. On the contrary, purified soluble beef heart DPN-cytochrome *c* reductase (*29*), kindly provided by H. R. Mahler, did not show any tocopherol effect by the extraction method; nor did purified pig liver TPN-cytochrome *c* reductase (*30*), kindly furnished by B. L. Horecker, respond to the same procedure. A marked enhancement of both succinate- and DPN-cytochrome *c* reductase by tocopherol in ammonium sulfate fractions of human pectoral muscle after isooctane treatment has also been demonstrated; this constitutes tentative evidence for a functional requirement of tocopherol in man.

Mattill (*2*) has very aptly stated that "the search for some unifying principle or correlating ideas as to the manner of action [of vitamin E] has not been rewarding." Whether the presently indicated function of the tocopherols, perhaps in a conjugated form, represents its primary role remains to be proved. The relationship between a possible natural lipid cofactor and the tocopherols, their possible implication in oxidative phosphorylation, and the behavior of the cytochrome *c* reductase of dystrophic muscle in both human and vitamin-E-deficient organisms are now under investigation.

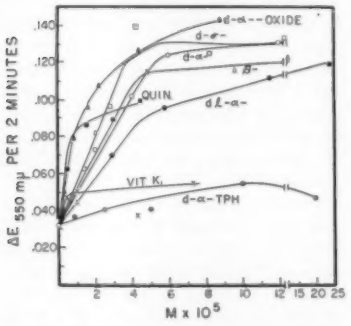


Fig. 2. Effect of the tocopherols and other fat-soluble compounds in reactivating a soluble preparation of isooctane-extracted DPN-cytochrome *c* reductase from rat skeletal muscle. The reaction mixture contained 0.05 ml of enzyme (66 μg of protein), 0.10 ml of 2-percent aqueous cytochrome *c*, 0.3 ml of $10^{-2}M$ KCN, 0.1 ml of DPNH (1.15 μmole/ml), the indicated fat-soluble compounds suspended in 15-percent ethanol-2-percent bovine serum albumin, and $10^{-1}M$ tris-(hydroxymethyl)-aminomethane buffer (*p*H 7.9) to give a final volume of 3.0 ml. The disodium salt of D-α-tocopheryl phosphate and vitamin K_1 were added as aqueous and alcohol solutions, respectively. D-α-Tocopherol, ○——○; D-γ-tocopherol, □——□; β-tocopherol, △——△; DL-α-tocopherol, ●——●; D-α-tocopheroxide, ▲——▲; D-α-tocopheryl quinone, ■——■; D-α-tocopheryl phosphate, disodium salt, ⊕——⊕; vitamin K_1, ×——×. The enzyme was extracted once with isooctane, as is described in Fig. 1.

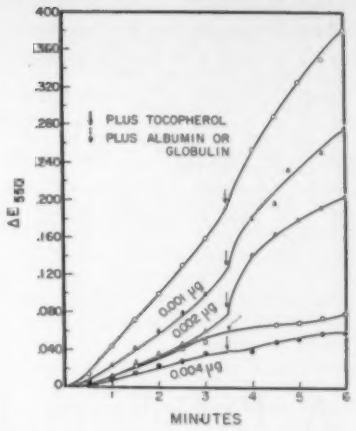


Fig. 3. Antimycin-A inhibition of soluble DPN-cytochrome *c* reductase from rat skeletal muscle and its partial reversal by tocopherol. The control reaction mixture contained 0.1 ml of digitonin-solubilized enzyme (120 μg of protein), 0.04 ml of 2-percent aqueous cytochrome *c*, 0.1 ml of $10^{-2}M$ KCN, 0.04 ml of DPNH (1.15 μmole/ml), and $10^{-1}M$ tris(hydroxymethyl)aminomethane buffer (*p*H 7.9) to give a final volume of 1.0 ml. As indicated, 0.02 ml of absolute ethanol containing various concentrations of antimycin A were added at zero time; control, ○——○; 0.001 μg, antimycin A, ▲——▲; 0.002 μg antimycin A, △——△ and □——□; .004 μg antimycin A, ●——●. Three minutes after the reactions had been started the following additions were made as indicated: 0.02 ml D-α-tocopherol (4.3 μmole/ml) in a 15-percent ethanol-2-percent human γ-globulin suspension; 15-percent ethanol-2-percent human γ-globulin; 15-percent ethanol-2-percent bovine serum albumin.

References and Notes

1. R. M. Herriott, Ed. *Symposium on Nutrition* (Johns Hopkins Univ. Press, Baltimore, 1953), pp. 136, 179, 198. K. E. Mason, Ed., "Vitamin E," *Ann. N.Y. Acad. Sci.* 52, 63 (1949). W. H. Eddy, *Vitaminology* (Williams and Wilkins, Baltimore, 1949), p. 60.
2. H. A. Mattill, *Nutrition Revs.* 10, 225 (1952).
3. W. H. Sebrell, Jr., and R. S. Harris, Eds., *The Vitamins, Chemistry, Physiology, Pathology* (Academic Press, New York, 1954), vol. 3, p. 481.
4. O. B. Honchin, *J. Biol. Chem.* 146, 313 (1942).
5. ——— and H. A. Mattill, *ibid.* 146, 301, 309 (1942).
6. D. H. Basinski and J. P. Hummel, *ibid.* 167, 339 (1947).
7. M. Goettsch and E. F. Brown, *ibid.* 97, 549 (1932).
8. J. P. Hummel, *ibid.* 172, 421 (1948).
9. M. Rabinovitz and P. D. Boyer, *Proc. Soc. Exptl. Biol. Med.* 77, 103 (1951).
10. H. Bloch, *Helv. Chim. Acta* 25, 793 (1942).
11. C. Van Der Meer and H. T. M. Nieuwerkerk, *Biochim. et Biophys. Acta* 7, 263 (1951).
12. W. M. Govier, V. Bergman, K. H. Beyer, *J. Pharmacol. Exptl. Therap.* 85, 143 (1945).

13. S. R. Ames, *J. Biol. Chem.* **169**, 503 (1947).
14. W. M. Govier and N. S. Jetter, *Science* **107**, 146 (1948).
15. K. L. Zierler, D. Grob, J. L. Lilienthal, Jr., *Am. J. Physiol.* **153**, 127 (1948).
16. H. P. Jacobi, J. W. Chappell, S. Morgulis, *Federation Proc.* **6**, 136 (1947).
17. W. H. Miller and A. M. Dessert, *Ann. N.Y. Acad. Sci.* **52**, 167 (1949).
18. T. R. Holman, *Arch. Biochem.* **15**, 403 (1947); H. O. Kunkel, *ibid.* **30**, 306 (1951).
19. M. Rabinovitz and P. D. Boyer, *J. Biol. Chem.* **183**, 111 (1950).
20. L. Michaelis and S. H. Wollman, *Biochim. et Biophys. Acta* **4**, 156 (1950).
21. P. D. Boyer, *J. Am. Chem. Soc.* **73**, 733 (1951).
22. Contribution No. 115 of the McCollum-Pratt Institute. A report of this work, as presented here, was given at the Federation meetings in April 1955 [A. Nason and I. R. Lehman, *Federation Proc.* **14**, 259 (1955)]. We are indebted to Bella C. Averbach for her invaluable technical assistance.
23. Crystalline bovine serum albumin and human γ-globulin were generously provided by Walter L. Hughes.
24. L. Smith, *Methods in Enzymology*, S. P. Colowick and N. O. Kaplan, Eds. (Academic Press, New York, in press).
25. The various tocopherols and their derivatives used in this study were generously supplied by the Distillation Products Division of the Eastman Kodak Co. Some of the D-α-tocopherol used in a number of the experiments reported here, as well as vitamin K_1, menadione, and vitamin D were generously donated by Merck and Co. The antioxidants nordihydroguiaretic acid, santoflex B, propylparasept, dibutyl *p*-cresol, diphenyl *p*-phenylenediamine, and santoquin were kindly provided by Klaus Schwartz.
26. Described in a personal communication from Klaus Schwartz.
27. F. Brown, *Biochem. J.* (*London*) **51**, 237 (1952).
28. H. Lineweaver and D. Burk, *J. Am. Chem. Soc.* **56**, 658 (1934).
29. H. R. Mahler *et al.*, *J. Biol. Chem.* **199**, 585 (1952).
30. B. L. Horecker, *ibid.* **183**, 593 (1950).

A. P. Colburn, Humanitarian and Chemical Engineer

In the death of Allan Philip Colburn on 6 February 1955, chemical engineering lost one of its most distinguished men and science, a great humanitarian. In an age of narrow specialization, Colburn stood out for his breadth and depth of interests and for a remarkable combination of the best of science and culture. He was conversant with literature, philosophy, and economics, and he devoted some of his little leisure to painting. He found time for an active part in the Delaware chapter of the American Red Cross, the Delaware branch of the American Cancer Society, his church, and other community activities. When I saw him shortly before his death, he was discussing plans for assisting in a program to improve the quality of teaching in the Delaware schools. Seldom has one man encompassed so much so well.

Allan P. Colburn was born in Madison, Wisconsin, on 8 June 1904, the son of Willis Paul Colburn, high-school principal, and Jane Grimm Colburn. After 2 years at Marquette University, he transferred to the University of Wisconsin where he was awarded a B.S. degree in 1926, an M.S. degree in 1927, and a Ph.D. degree in chemical engineering in 1929. His thesis, "Studies in heat transmission," was published by the Wisconsin Engineering Experiment Station in 1930 and stands as a classic in this field and a major stimulus to the work in heat transmission and mass transfer that has followed. The achievement was the more remarkable because he had only foreign literature to guide him and had to construct most of his own equipment. From this auspicious beginning, he went on to make significant contributions and published a long list of technical papers on heat transfer, fluid flow, distillation, absorption and extracting, and other subjects.

During the years 1929–38 at the experimental station of the E. I. duPont de Nemours and Company in Wilmington, Colburn not only matured in his science but also fought a long battle with tuberculosis, which left him with only one functioning lung and a deepened sense of social responsibility and personal idealism. While he was at Saranac Lake he won the first Walker award for outstanding publications in chemical engineering and in 1948 was the first recipient of the Professional Progress award of the American Institute of Chemical Engineers. In 1951 he was selected to deliver the principal address in London, England, at a symposium on heat transmission held jointly by American and European engineering societies. He was honored with a Civilian Service award in 1954 and posthumously with a certificate of achievement for his services as chairman of the U.S. Army Chemical Corps Advisory Council.

His public service during World War II was substantial and, typically, went far beyond a wise use of his limited physical resources. Important war research was carried on by the department of chemical engineering at the University of Delaware, a department that he organized and headed. He served on the National Defense Research Committee, on the National Advisory Committee for Aeronautics, at the Office of Rubber Reserve, and as a consultant to strategic war industries. With B. F. Dodge of Yale University, he prepared the curriculum on chemical engineering for the AST program that was taught throughout the war.

His keen sense of responsibility to his profession and to science as a whole was reflected in his positions in a wide range of professional societies. His honorary societies included Phi Kappa Phi, Phi Lambda Upsilon, Tau Beta Pi, and Sigma Xi.

In his capacities as assistant to the president, acting president, and provost of the University of Delaware, Colburn demonstrated his appreciation of the importance of developing research in the social sciences and of the broadening influences of educational programs for students which fostered the understanding of human relations and international problems.

President John A. Perkins of the University of Delaware has expressed well what all of Allan Colburn's friends and associates would want to say of him: "The most wonderful quality about him was his ability to inspire others with his own infectious enthusiasm. The breadth of his interest grew not only out of his active intellect but also out of his deep human sympathy. When he heard of other people's problems and concerns, they immediately became his own, and his active mind was driven to learn more about them. This quality made him a great teacher as well as an outstanding scientist. His creative talents, balanced by his vast store of scientific information, enabled him to make significant contributions to engineering education and higher education generally."

JOHN A. BEHNKE
American Association for the Advancement of Science, Washington, D.C.

News of Science

New AAAS Advertising Manager

Earl J. Scherago, former Chicago district advertising manager for *Analytical Chemistry*, has been appointed advertising representative for the two AAAS journals, *Science* and *The Scientific Monthly*, effective 1 July. Scherago, a Cornell University chemistry major, whose graduate studies were divided between bacteriology and electron microscopy, previously served for 5 years as technical representative for the Aloe Scientific Co., distributors and manufacturers of laboratory instruments. The Association has established an advertising office at 11 W. 42 St., New York 36, which will be under Scherago's direction.

Petition to the President

Four physicians have announced that a petition urging fundamental changes in the Federal security program has been presented to President Eisenhower. It is signed by more than 1500 leading medical men. Paul Klemperer, professor of pathology at Columbia University College of Physicians and Surgeons, Edwards A. Park, emeritus professor of pediatrics at Johns Hopkins University Medical School, Bela Schick, emeritus professor of pediatrics at Columbia University College of Physicians and Surgeons, and John F. Fulton, professor of the history of medicine at the Yale University School of Medicine released the text of the petition on 12 June. At that time they stated:

"The petitioners, who include some of the most eminent figures in American academic and research medicine, protest the harmful effects of the Program in discouraging 'the participation of highly qualified physicians in research projects and programs vital to the health of the nation.'"

The petition cites the case of John Punnett Peters [*Science* **121**, 838 (24 June)]. It does not deal with specific aspects of the Peters case, but the petitioners strongly uphold the principles stated in Peters' appeal to the court. The four physicians who released the statement said that since the court did not deal with the constitutional matters contained in the brief, it becomes all the more important that the President make the fundamental and necessary modifications in the security program so that the nation's health will in no way be jeopardized by arbitrary and restrictive procedures. The petition reads in part:

"As citizens, we are deeply troubled by these departures from traditional American methods of adjudication, which are rightly regarded as essential elements of our democratic heritage. As physicians, we are more particularly concerned by the discernibly harmful impact of such proceedings upon our special field of work. . . .

"We therefore urge you, Mr. President, to give serious consideration to this petition which we hope may be instrumental in initiating needed changes, to the end that a security program may be devised which while fully protecting the security of our nation, more adequately safeguards the interests of individuals—who, after all, compose the nation."

The petition was initiated by 53 prominent physicians, and it was subsequently signed by medical men in 38 states, the District of Columbia, Hawaii, and Alaska. Although the document was submitted to the President some weeks ago, the signers withheld public announcement of their action until the Supreme Court had ruled on the related matter in the case of Peters. This delay in public release was motivated by a desire not to prejudice a pending judicial matter.

The initiating sponsors of the petition are Murray H. Bass, Mount Sinai Hospital, New York; Allan M. Butler, Harvard; Willian B. Castle, Harvard; Benjamin Castleman, Harvard; Stanley Cobb, Harvard; Katherine Dodd, University of Arkansas; J. Russell Elkinton, University of Pennsylvania; John F. Fulton, Yale; James L. Gamble, Harvard; Alfred Gellhorn, New York; Harry Greene, Yale; Charles M. Grossman, Portland; Emile Holman, Stanford; Charles A. Janeway, Boston; Paul Klemperer, Columbia; Louis Leiter, New York; Leo Mayer, New York; J. Howard Means, Boston; Max Michael, Jr., State University of New York; Carl V. Moore, Washington University; Hugh Morgan, Vanderbilt; Edwards A. Park, Johns Hopkins; Ephraim Shorr, New York; William C. Stadie, University of Pennsylvania; Eugene A. Stead, Jr., Duke; Joseph Stokes, Jr., University of Pennsylvania; Somers H. Sturgis, Boston; Alfred H. Washburn, University of Colorado; Paul D. White, Boston; W. Barry Wood, Jr., Washington University; I. Ogden Woodruff, New York; S. Bernard Wortis, New York; Edward Young, Boston.

Russell L. Cecil, Cornell; David Crocker, Western Reserve; Dana L. Farnsworth, Harvard; James M. Faulkner, Boston University; Jacob Fine, Boston; Harry Goldblatt, Cleveland; Louis S. Goodman, University of Utah; Harry H. Gordon, Johns Hopkins; Chester M. Jones, Harvard; Samuel A. Levine, Boston; H. Houston Merritt, Columbia; Richard M. Peters, University of North Carolina; Grover F. Powers, Yale; Lawrence J. Roose, New York; Bela Schick, New York; Benjamin Segal, New York; Milton J. E. Senn, Yale; Kenneth Sterling, Syracuse; Jay Tepperman, Syracuse; Maurice B. Visscher, University of Minnesota.

Scopes Anniversary

Thirty years ago this summer world attention was focused on Dayton, Tenn., where a young science teacher, John T. Scopes, was on trial for teaching evolution, a crime under the laws of the state. William Jennings Bryan, three times the Democratic candidate for President and a fundamentalist believer in the Bible, served as chief counsel for the prosecution. Chief counsel for the defense was the agnostic, Clarence Darrow, then the nation's greatest criminal lawyer. Assisting Darrow was Arthur Garfield Hays, the eminent attorney for the American Civil Liberties Union who died last year.

Early in 1925 the ACLU announced that it wanted to test the Tennessee antievolution statute, and it was a Tennessee friend of the union, George Rappleyea, who persuaded Scopes to press his case. The $10,000 needed to finance the defense was raised chiefly through an appeal to members of the AAAS.

Scopes was convicted and fined $100, but the Tennessee antievolution law, which is still on the statutes, has been dead ever since. Darrow may have lost his case, but he won a victory that has a permanent place in history.

A successful play about the Scopes trial, *Inherit the Wind*, opened recently in New York. In his review, Walter Kerr of the New York *Herald Tribune* said: "The intellectual positions are there, 'the right to think' versus the right of the State to make laws prohibiting discussion. . . . The outcome of the battle . . . is known; if the battle itself, in other forms, continues to be fought in 1955, there is still no suspense about the nature or validity of the point. . . ."

Climatic Thermal Adaptation

In a paper devoted to the evolution of climatic adaptation in homeotherms, [*Evolution* **9**, 15 (Mar. 1955)], P. F. Scholander points out that heat dissipation is the only main avenue for climatic thermal adaptation in birds and mammals. The "critical temperature," the lowest air temperature at which a bird or mammal can rest at a basal heat production, is a fundamental measure of overall climatic thermal adaptation. The lower critical temperatures found in arctic species result chiefly from the heavy body insulation of fur or feathers, together with marked tolerance of low tissue temperatures in poorly insulated peripheral parts, such as legs, tail, and face, in which vascular control governs heat dissipation.

Scholander questions the validity of regarding the minor and erratic subspecific trends expressed in Bergmann's and Allen's rules as reflecting phylogenetic pathways of heat conservation. Behind both of these rules is the idea that in going to colder environments the total surface area of animals, relative to weight, should decrease, bringing about a decrease in heat loss. Scholander points out, however, that cold climates do not produce large, globular species with small protruding parts. Apparently, then, surface area as such has not been a factor of general morphogenic importance in the evolution of races found in hot or cold climates; and this would seem to apply to man as well as to other homeotherms.—W.L.S., JR.

Quick Morphine Detection

Development of a rapid and simple method of detecting morphine in body fluids and tissues has been reported by a group of pharmacologists at the University of California Medical Center in San Francisco. The method will prove useful in the diagnosis of morphine poisoning and in the detection of the presence of the drug in suspected addicts and in attempted suicides, and it may become a useful tool of pathologists doing post mortems. The method is already being used in several California diagnostic laboratories.

In the past no simple method has been available because of the difficulty of separating morphine from biological materials. Although various new scientific techniques, such as counter current distribution, paper chromatography, and electrophoresis, are useful in separating morphine, such methods require very special laboratory equipment and are often time-consuming.

The medical center group has developed a single extraction process, using routine chemical equipment, which permits determination of morphine in urine in less than 90 min. This is the fastest method so far developed. The drug can be detected in quantities as small as 1/100,000 g.

The research was carried out by James M. Fujimoto, teaching assistant in pharmacology and toxicology, Charles H. Hine, and E. Leong Way, associate professor of pharmacology and toxicology.

■ The Department of Agriculture and the Department of State have announced that 12 representatives of American agriculture will comprise a delegation scheduled to visit the U.S.S.R. between 15 July and 15 Aug. Since the visit to the Soviet Union will be unofficial, no provision will be made for payment of travel expenses from U.S. Government funds. The delegation will be broadly representative of American agriculture, and its members will be persons who are recognized in farming and in agricultural research and extension. It is understood that the itinerary will include various rural areas of the Soviet Union and agricultural research and educational institutions.

Several hundred persons have expressed interest in making the trip. The national farm organizations, Iowa State College, and other land-grant colleges have been invited to make preliminary nominations. Final selections will be made by a nonofficial public group to be designated.

The visit to the U.S.S.R. is of a reciprocal nature. The Soviet Union is sending to the United States an agricultural delegation of similar size during the approximate period 10 July to 10 Aug. A considerable amount of time will be spent in Iowa, in accordance with the expressed Soviet interest in corn-hog production.

■ Jacob Bjerknes and Yale Mintz of the meteorology department of the University of California at Los Angeles have completed a 6-year study that may make it possible to forecast weather for a whole hemisphere. The project was sponsored by the U.S. Air Force's Geophysical Directorate.

■ Representatives of the governments of Switzerland and the United States have initialed a 5-year agreement for cooperation in connection with the purchase by Switzerland of the research reactor that is to be a central feature of the official U.S. exhibit at the United Nations' International Conference on Peaceful Uses of Atomic Energy at Geneva, 8–20 Aug. Under the provisions of the U.S. Atomic Energy Act of 1954, certain procedural steps must be taken by the executive and legislative branches of the U.S. Government before the initialed agreement may be signed and entered into force.

The price of the reactor, building, associated machinery, and exhibits is to be $180,000. The United States will lease to Switzerland sufficient enriched uranium for initial and replacement fuel for the reactor. The quantity of uranium under such lease shall not contain more than 6 kg of U^{235} (maximum enrichment, 20 percent), plus such additional quantity as the AEC may deem necessary to permit the efficient and continuous operation of the reactor while replaced fuel elements are radioactively cooling in Switzerland or while fuel elements are in transit.

■ Plans for six more nuclear reactors were announced in the British House of Commons on 13 June. These are in addition to the 12 commercial atom stations scheduled in the 10-year program authorized in February [*Science* **121**, 324 (4 Mar. 1955)]. The commercial stations are being built for the Central Electricity Authority. The six new reactors are for the British Atomic Energy Authority.

They are to be dual-purpose plants. Their production of fissile material will greatly strengthen Britain's military potential; they will also produce electricity for the national grid system. The new atom plants are expected to make "a useful contribution" to Britain's fuel supplies within the next 5 years.

The first two of the CEA's commercial atom stations are also scheduled to be in operation by 1961. According to the original plan, nuclear power would be providing one-quarter of Britain's requirements for new electricity generating capacity by 1965. This now appears to be an underestimate.

■ On 22 June the HMTS *Monarch* weighed anchor and proceeded northeastward from Newfoundland. The British ship's mission is the laying of the first transoceanic telephone cable—spanning the Atlantic between Newfoundland and Scotland. The project is a joint undertaking of the American Telephone & Telegraph Co., the British Post Office, and the Canadian Overseas Telecommunication Corp. and will cost about $40 million. Service is scheduled to be established late in 1956.

The *Monarch* must lay a cable across 2000 mi of ocean bottom by summer's end, for summer is the only time the Atlantic is calm enough to permit such an undertaking. The ship can lay up to 6 nautical miles of cable per hour. A second cable is to be laid from Scotland to Newfoundland in the summer of 1956.

The new twin-cable system will greatly improve the telephone service between

the United States and Great Britain. This service was inaugurated in 1927 and is handled entirely by radiotelephone.

Each of the transatlantic cables will be equipped to transmit speech in one direction: thus voices from New York will travel eastward over one cable, and voices from London will be carried westward over the second cable. The system will be able to carry 36 conversations at the same time, almost tripling the present radiotelephone capacity between the United States and Great Britain.

In 1927, when radiotelephone service was initiated, there were 2000 calls made. The annual telephone traffic between the two countries today is more than 30 times as heavy.

■ The widely held belief that cattle do not sweat has now been disproved by research conducted by the Commonwealth Scientific and Industrial Research Organization in Sydney, Australia. Investigators compared a purebred Ayrshire calf with two Zebu-cross calves. The animals were kept in a hotbox and a small, shaved area of the coat was examined for traces of sweat. All three calves produced beads of sweat. The Zebu-cross calves produced about 4 times more sweat than the pure British breed.

The Zebu-cross calves kept their temperature normal at 102°F when they were in a hotbox at 115°F. The temperature of the purebred British calf rose to 105°F under the same conditions, and it showed signs of heat distress. It seems likely that the greater amount of sweat produced by the Zebu-cross calves helped them adjust satisfactorily to the hot environment.

Scientists in the News

GERTRUDE D. MAENGWYN-DAVIES, assistant professor of ophthalmology in the Wilmer Institute, Johns Hopkins Medical School, has been appointed an associate research professor in the department of pharmacology at the George Washington University Medical School, Washington, D.C., effective 1 July.

In a presentation ceremony that took place at Washington University (St. Louis) on 6 June, ALLEN O. WHIPPLE, professor emeritus of surgery at the College of Physicians and Surgeons of Columbia University, received the first Graham award for outstanding contributions to surgery. Funds for the award were set up by associates and former students of EVARTS A. GRAHAM, emeritus Bixby professor of surgery at Washington, at the time of his retirement in 1951. The medal will be awarded every 3 or 4 years to the surgeon who, in the opinion of the selection committee, has made the most significant contributions to his profession.

Whipple is director of a new project by which the American College of Surgeons will be associated with the U.S. Foreign Operations Administration in bringing to this country doctors from the NATO countries who might train in American hospitals.

Two new appointments in the department of mechanical engineering at Massachusetts Institute of Technology are as follows: KNOX MILLSAPS, chief of the applied mathematics research branch at the Wright Air Development Center, Wright Patterson Air Force Base, Dayton, Ohio, will be visiting professor for the 1955–56 academic year; and, effective 1 July, JAMES A. FAY, assistant professor in the department of engineering mechanics at Cornell University, will become an associate professor.

Last month ROBERT C. BERSON, dean of the Medical College of the University of Alabama, was formally installed as the university's vice president for health affairs.

Both Berson and THOMAS F. PAINE, Jr., professor of microbiology, have recently accepted additional appointments as professors of medicine. These appointments are on a voluntary basis; each man will offer his services from time to time when called upon by the chairman of the department.

W. MAURICE EWING, director of Columbia University's Lamont Geological Observatory, Palisades, N.Y., and a pioneer scientist in underwater sound research, has received the U.S. Navy's Distinguished Public Service award for his outstanding contributions to the science of undersea warfare. The presentation was made by Assistant Secretary James H. Smith, Jr., in a ceremony that took place in Washington on 31 May.

For his outstanding contributions to gliding, RALPH S. BARNABY, chief of the aeronautics section of the Franklin Institute Laboratories for Research and Development, was honored by the Federation Aeronautique Internationale during its 1955 General Conference in Paris, 1–25 June. He received a Paul Tissandier diploma, awarded annually by the FAI to representatives of the various member nations "who by their action, work, initiative, their devotion or any other manner, serve the cause of aviation in general, and private and sporting aviation in particular."

An especially prepared issue (May 1955) of the *Stanford Medical Bulletin* has been dedicated to ARTHUR L. BLOOMFIELD, emeritus professor of medicine, by more than 150 former students and colleagues. A tribute written by Emile F. Holman, head of Stanford Medical School's department of surgery, describes the noted internist as a "profound student, incomparable teacher, superb diagnostician, and relentless foe of the pusillanimous."

Bloomfield, who retired last year as head of the department of medicine after 26 years of teaching at Stanford, was particularly well-known for his ward rounds. Holman says: "His ward rounds were a delight. In the midst of a scholarly medical review he would suddenly present an apt quotation from Cicero or Shakespeare or the more homely philosopher, O. Henry, to give color, point, and zest to his teaching."

JOSEPH T. VELARDO, research associate at the Harvard Medical School and the Peter Bent Brigham Hospital, Boston, is the recipient of the Rubin award for his work in reproductive physiology and sterility. He was honored during the annual meeting of the American Society for the Study of Sterility that took place in Atlantic City, N.J., 4–5 June. Velardo's paper "Effect of various steroids on gestation and litter size in rats" helped bridge the gap between basic studies and clinical applications.

ARTHUR KNUDSON, professor of biochemistry at the Albany Medical College, will depart in July for Djakarta, Indonesia, where he will serve as visiting professor of biochemistry. During the 2-year appointment he will participate in the University of California–University of Indonesia project in medical education that is being sponsored by F.O.A.

The council of the Royal College of Surgeons of England has announced that LOYAL DAVIS, chairman of the department of surgery at Northwestern University Medical School, who is known for his work in surgery of the nervous system, has received an honorary fellowship.

The fellowship is awarded to outstanding surgeons who have made significant contributions to their field. The Royal College also awarded fellowships to ROBERT JANES of Toronto, Canada, and WILLIAM DOOLIN of Dublin, Ireland.

CARL R. MOORE, professor and chairman of the University of Chicago's department of zoology, has been awarded the first Endocrine Society medal. The medal has been established to honor distinguished scientific research in the study of the endocrine glands.

Moore is one of the pioneers in the study of sex glands and hormones. His researches began almost 40 years ago and have led to new information on sex-

gland transplantation, the function of sex hormones secreted by living tissues, the conditions under which germ cells are produced, and a test for the male sex hormone. Research at the University of Chicago in which Moore played a leading role formed the foundation for medical progress in the treatment of prostate cancer in men and breast cancer in women.

RUSSELL J. SEIBERT, director of the department of Arboreta and Botanic Gardens for Los Angeles County, Calif., has been appointed director of the Longwood Gardens near Kennett Square, Pa., effective 15 July. The appointment was announced by Henry B. du Pont, president of the Longwood Foundation, which operates the gardens.

JAMES B. FISK, vice president in charge of research for Bell Telephone Laboratories, was elected executive vice president on 1 June. In his new post Fisk is directly responsible for all technical activities of Bell Laboratories as well as continuing as head of research.

Also effective on 1 June, ESTILL I. GREEN, director of military communication systems, was elected vice president in charge of systems engineering.

At the same time five new general department heads were named: M. L. ALMQUIST is director of systems engineering I; P. W. BLYE is director of systems engineering II; F. J. SINGER is director of systems engineering III; J. A. MORTON is director of device development under the vice president in charge of switching and transmission developments; and R. R. HOUGH is director of military electronics development II.

RAYMOND R. DICKISON, former head librarian at the Colorado School of Mines, has been named chief librarian for Oak Ridge National Laboratory.

KANEMATSU SUGIURA, associate of the Sloan-Kettering Institute for Cancer Research, New York, has been appointed an honorary member of the Japanese Cancer Association. He had an audience with Emperor Hirohito on 27 Apr.

DONALD F. MARLOWE, associate technical director for engineering at the U.S. Naval Ordnance Laboratory, Silver Spring, Md., resigned on 1 July to become dean of engineering and architecture at Catholic University. During his 14 years at NOL, Marlowe has become an authority on the applications of the theory of elasticity to mine structure.

He is succeeded by DAVID S. MUZZEY, who has served as chief of the engineering department for the past 3 years. In his new post Muzzey has supervisory responsibility for four NOL departments: engineering, underwater ordnance, fuze, and technical evaluation. Muzzey is in turn succeeded by WILLIAM B. ANSPACHER, former deputy chief of the engineering department.

The following are among those who have recently received honorary doctoral degrees.

Oglethorpe University: MURRAY M. COPELAND, professor and director of the department of oncology, Georgetown University Medical Center.

Smith College: CAROLINE BEDELL THOMAS, associate professor of medicine, Johns Hopkins University School of Medicine.

Pomona College: AVERY S. HOYT, chief of the U.S. Bureau of Entomology and Plant Quarantine.

University of Oxford: KING GUSTAF VI ADOLF of Sweden, archeologist.

New York University: EDGAR DOUGLAS ADRIAN, Nobel laureate in physiology and master of Trinity College, Cambridge University, England; GEORGE PACKER BERRY, dean of the Harvard Medical School; VINCENT DU VIGNEAUD, chairman of the department of biochemistry, Cornell University Medical College; EVARTS AMBROSE GRAHAM, surgeon and emeritus professor at Washington University School of Medicine; BERNARDO ALBERTO HOUSSAY, Nobel laureate and director of the Institute of Medicine and Experimental Biology, Buenos Aires, Argentina; KAJ ULRIK LINDERSTRØM-LANG, director of the Carlsberg Laboratory, Copenhagen, Denmark; ROBERT FREDERICK LOEB, chairman of the department of medicine, Columbia University; THOMAS PARRAN, dean of the School of Public Health, University of Pittsburgh, and formerly Surgeon General of the U.S. Public Health Service; WILDER GRAVES PENFIELD, professor of surgery and neurosurgery, McGill University, Canada, and founder and director of the Montreal Neurological Institute; LOWELL JACOB REED, president of the Johns Hopkins University; ALFRED NEWTON RICHARDS, professor emeritus of pharmacology and vice president in charge of medical affairs of the University of Pennsylvania, and former president of the National Academy of Sciences; JONAS EDWARD SALK, discoverer of the vaccine for the prevention of poliomyelitis and director of the Virus Research Laboratories of the School of Medicine, University of Pittsburgh; HOWARD CANNING TAYLOR, JR., professor of obstetrics and gynecology, Columbia University.

Ohio State University: MELVIN DE GROOTE, vice president, Petrolite Corp.; HOMER C. FRITSCH, executive vice president, Parke, Davis and Co.

Monmouth College: P. A. WELLS, chief of the Eastern Utilization Research Branch, U.S. Agricultural Research Service.

North Carolina State College: ELWOOD L. DEMMON, director, Southeastern Forest Experiment Station.

Pratt Institute: WALTER LEO WEIBLE, Deputy Chief of Staff for Operations and Administration, U.S. Army.

Worcester Polytechnic Institute: CLARENCE H. LINDER, vice president for engineering, General Electric Co.; HAROLD S. BLACK, research engineer, Bell Telephone Laboratories, Inc.; MILTON P. HIGGINS, president of Norton Co.

Lehigh University: FRANK M. MASTERS, bridge designer; WILMER A. DEHUFF, principal of the Baltimore Polytechnic Institute.

Columbia University: FELIX ANDRIES VENING-MEINESZ, geophysicist, University of Utrecht, Netherlands.

The following appointments to assistant professor have been announced: University of Illinois: LEO F. KOCH, biology. Western Michigan College: NATHAN NICHOLS, physics; JAMES H. POWELL, mathematics; CAROLA TRITTIN, paper technology.

Necrology

WALTER C. BAKER, 87, pioneer automotive manufacturer, Baker-Raulang Co., Cleveland, Ohio, 26 Apr.; MADISON BENTLEY, 84, psychologist, author, and editor, and former chairman of the department of psychology at Cornell University in Ithaca, N.Y., Palo Alto, Calif., 29 May; CARLE M. BIGELOW, 65, retired chemical and management expert, Fine Chemicals Division of the American Cyanamid Co. in Somerville, N.J., Bound Brook, N.J., 10 May.

WALTER H. DANE-DWORECKI, ear, nose, and throat specialist and chief of otolaryngology at the Veterans Administration Hospital in Albuquerque, N.M., London, England, 18 May.

GUSTAV EGLOFF, 69, petroleum scientist, research director for the Universal Oil Products Co. of Des Plaines, Ill., former president of the American Institute of Chemists and of the Western Society of Engineers, Chicago, 29 Apr.; ADOLPH ELWYN, 67, associate professor of neuroanatomy at Columbia University College of Physicians and Surgeons in New York, Briarcliff Manor, N.Y., 9 June; R. WILLIAM ESHMEYER, 50, fisheries expert, executive vice president of the Sport Fishing Institute and former head of fisheries research for the Tennessee Valley Authority in Knoxville, Tenn., Arlington, Va., 20 May.

THADDEUS REAMY GILLESPIE, 59, assistant professor of obstetrics at the University of Cincinnati College of Medicine, Cincinnati, Ohio, 21 Apr.; ISAAC

GLASSMAN, 64, roentgenologist and diagnostician and author, New York, 5 May; NATHAN W. GREEN, 84, retired surgeon, founder and former president of the American Society of Thoracic Surgery, Norwalk, Conn., 21 Apr.; ALBERT F. GUITERAS, 50, consulting chemist and director of Hudson Laboratories, former research coordinator, treasurer, and director of bacteriology and toxicology for Foster D. Snell, Inc., New York, 26 May.

ABNER KURTIN, 43, dermatologist and syphilologist, founder of the Albert Einstein College of Medicine of Yeshiva University, New York, 11 May.

GEORGE MILLER MACKEE, 77, dermatologist, professor emeritus of dermatology at New York University, consultant at Stamford and St. Joseph's hospitals in Stamford, Conn., and St. Luke's and St. Vincent's hospitals in New York, Stamford, Conn., 8 May; HARRY MANDELBAUM, 60, assistant in medicine and director of the hypertension clinic at the Jewish Hospital in Brooklyn, N.Y., and clinical professor of medicine at the State University of New York College of Medicine in Brooklyn, New York, 27 May; JOHN PUTNAM MARBLE, 58, research geochemist, chairman of the committee on measurement of geologic time of the division of geology and geography, National Research Council, Washington, D.C., 6 June; C. ERNEST MILLAR, 69, agronomist, retired head, department of soil science, Michigan State University in East Lansing, Beverly Hills, Calif., 27 Mar.

GROVER CLEVELAND NANCE, 72, former head of the geology and geography department of Winthrop College, Rock Hill, S.C., 24 May; PAUL SUMMER NICKERSON, 63, associate professor of education and psychology at The Citadel, Charleston, S.C., 15 May.

JOSEPH I. PASCAL, 65, ophthalmologist, adjunct ophthalmological surgeon at the Hospital for Joint Diseases, Beth David Hospital, and Harlem Eye and Ear Hospital, director of the eye department of Stuyvesant Polyclinic Hospital, and cofounder and former director of the American Institute of Optometry, New York, 22 Apr.; EDWARD C. PFAHL, 78, engineering consultant, Brookhaven, Miss., 18 Apr.; HAROLD ROMAINE PHALEN, 66, head of the department of mathematics at the College of William and Mary, Williamsburg, Va., 30 May; GEORGE W. MACPHERSON PHILLIPS, 67, chemical engineer with the U.S. Department of Agriculture's Eastern Utilization Research Branch, Philadelphia, Pa., 24 Apr.

WILLIAM C. REAVIS, 73, psychologist and an emeritus professor of education at the University of Chicago, Chicago, Ill., 1 June; JAMES VINCENT RICCI, 64, clinical professor of gynecology and obstetrics at New York Medical College, consulting gynecologist and obstetrician at Beekman-Downtown and Columbus hospitals, New York, 11 May; LISLE A. ROSE, 51, professor of general engineering and director of University of Illinois engineering and information publications, Champaign, Ill., 23 May; S. LEWIS RUBINSOHN, 69, surgeon and chief of proctology at the Einstein Medical Center, Northern Division, Philadelphia, Pa., 1 May; A. DAVID RUSSELL, president of the Russed Pharmacal Corp., New York, 5 June.

FERDINAND R. SCHEMM, 55, heart specialist, a founding director of the Great Falls Heart Research Institute in Great Falls, Mont., St. Louis, 16 May; CARL ALWIN SCHENCK, 87, forester, founder of the first school of forestry in the United States, Lindenfels, Germany, 16 May; ALFRED A. SCHILLER, 39, associate professor of physiology at the University of Illinois College of Medicine in Chicago, Ill., Palo Alto, Calif., 21 Apr.

ISADORE M. TRACE, 75, heart specialist, a founding physician of Mount Sinai Hospital, Chicago, Ill., and professor of medicine at Chicago Medical School, Chicago, 4 May.

ITZHAK VOLCANI, 75, founder and head of the Jewish Agency's agricultural experiment station in Rehovoth, Tel Aviv, Israel, 24 May.

PAUL A. WEBSTER, 52, specialist in silica analysis and chemist for the Hartford Empire Co., Hartford, Conn., 23 Apr.; HARRY WEISS, 63, physician and bacteriologist, adjunct physician at Mount Sinai Hospital, associate attending physician at Sydenham Hospital, New York, 21 Apr.; JOE YOUNG WEST, 51, science professor at Towson State Teachers College, Towson, Md., 29 Apr.; DONALD W. WHITLOCK, 61, research engineer for Keuffel and Esser Co. of New York, Orange, N.J., 19 Apr.; JOSEPH A. WHITTINGTON, 57, post engineer at Blue Grass Ordnance Depot, Richmond, Ky., 24 Apr.

Education

■ Concern over the nation's short supply of scientific manpower led a University of California scientist to take a new step in solving that problem. Arthur B. Pardee, assistant professor of biochemistry and assistant research biochemist in the university's Biochemistry and Virus Laboratory at Berkeley, launched a program for placing high-school science students in research laboratories for summer work.

At the end of March Pardee wrote to science teachers in some 30 high schools throughout the San Francisco Bay area. He asked them to discuss with their outstanding science students the prospect of summer work in research laboratories at the University of California and suggested that the students apply for the positions by letter.

Some 40 applications were submitted. Since only about 10 jobs were available at the university, Pardee has talked with research laboratories in industry and in other universities in an effort to place the students.

■ Four new graduate programs, three of them leading to the Ph.D. degree, will be offered by the Stevens Institute of Technology next September. The new degrees can henceforth be earned in the departments of chemistry, mathematics, and physics, which already award advanced degrees at the master's level.

The fourth new degree toward which Stevens graduate students now will be able to work is that of master of science in civil engineering. This makes civil engineering the eighth department in which the master's degree can be earned.

The eight departments now offer graduate degrees in 15 major areas of specialization in engineering and science. The three new doctoral programs bring to four the number of departments awarding the doctorate. The department of mechanical engineering already accepts candidates for the degree of doctor of science in applied mechanics.

■ An engineering psychology section has been established in the electrical engineering division of the Franklin Institute Laboratories for Research and Development. Ezra S. Krendel, who joined the laboratories' staff in 1949, has been appointed section chief.

■ The New York University College of Engineering will inaugurate programs in nuclear engineering and engineering science in the fall, and Dean Thorndike Saville states that the college has discussed with the U.S. Atomic Energy Commission plans for construction this summer of a subcritical nuclear reactor for laboratory use. The new graduate program, for which the degree of master of nuclear engineering has been authorized, is the first in the New York metropolitan area and among the first in the country.

The planned subcritical reactor would be the first of its kind at a university. It cannot maintain a chain reaction and therefore is appropriate for university classroom studies. Economical, safe, and accurate for experiments in undergraduate and graduate education in nuclear engineering, it would be built at a cost of a few thousand dollars. (The cost of constructing and installing operating research and industrial reactors amounts to millions of dollars.) Uranium would be on loan from the AEC.

If the project is approved by the AEC, the installation will be tested this summer at Brookhaven National Laboratory, Upton, N.Y., and moved in September to the basement of Butler Hall on N.Y.U.'s University Heights campus in the Bronx. The reactor will consist of a 5-ft tank of water in which 2 tons of uranium rods are placed. The neutron source, consisting of polonium and beryllium, will be housed beneath floor level and can be hoisted up among the uranium rods by remote control.

The program in engineering science will lead to the degree of bachelor of engineering science. It is designed chiefly for students who intend to do postgraduate work directed toward research and development. Thus, after a 4-year program in engineering science, a student could take postgraduate work in any of the specialized engineering fields: civil, aeronautical, chemical electrical, mechanical, nuclear, and metallurgical.

■ Training in the fundamental background for the design and operation of automatic control systems for science and industry will be the basis of a new graduate program to be offered at Harvard University next fall. The program in control systems engineering will offer educational opportunities leading to both the M.S. and the Ph.D. degree through the division of engineering and applied physics, Graduate School of Arts and Sciences.

Applications of control systems range from the processing of raw materials to the packaging of finished goods. Specific uses apply to oil refining, machining of metals, classification of freight cars, traffic control, telephone operation, and scientific computation. The Harvard program will stress design of integrated control systems, veering away from the present practices of building components and attempting to fit these into a system.

The program material will draw on a variety of disciplines, including mathematics and mechanical and electrical engineering. Requirements for the M.S. degree include successful completion of eight half courses that are selected by the student with faculty approval. The new course should be completed in one academic year. The doctor's degree will entail a minimum residence of 2 years, culminating in a thesis describing original research.

These curriculums are open only to students who have been admitted to the graduate school. Applications for admission to the first class this fall may be filed *until 15 Aug.* at the office of the Dean of the Graduate School of Arts and Sciences, 24 Quincy St., Cambridge 38, Mass. After the first year (1956–57) and following, applications and supporting papers should be filed before 1 May.

Grants, Fellowships, and Awards

■ At its recent annual meeting in New York, the Engineering Foundation of 29 W. 39 St., New York 18, approved applications totaling $61,850 for the 1955–56 fiscal year. In a number of cases the grant is contingent upon the project's being able to raise outside support.

The grants will further 26 research programs being carried out in university laboratories all over the country under sponsorship of the major engineering societies. The investigations range from column research, which has been under way long enough to give definite promise of safer and less expensive structures, to a new research program for predicting disastrous storm surges in time to prevent serious loss of life.

■ The Louis W. and Maud Hill Family Foundation has made a grant of $54,000 to the University of Minnesota for the purpose of inaugurating a 4-year program of summer institutes for high-school teachers of the physical sciences and mathematics. The grant will cover the costs for the first 2 years, when it may be extended if the program is successful. The departments of physics, chemistry, and mathematics will cooperate in organizing a program designed to fit the needs of the teacher now serving in the secondary schools.

■ The American Dermatological Association is again offering a series of prizes for the best essays submitted for original work, not previously published, related to some fundamental aspect of dermatology or syphilology. The purpose of this contest is to stimulate investigators to original work in these fields. Cash prizes will be awarded as follows: $500, $400, $300, and $200 for first, second, third, and fourth place, respectively. Manuscripts typed in English with double spacing and ample margins, together with illustrations, charts, and tables, all of which must be in triplicate, are to be submitted *not later than 15 Nov.*

The manuscripts should be sent to Dr. J. Lamar Callaway, Secretary, American Dermatological Association, Duke Hospital, Durham, N.C. Applications that are incomplete in any of the afore-mentioned respects will not be considered. Manuscripts should be limited to 10,000 words or less, and the time required for presentation of the prize essay may not exceed 30 min.

In order to aid fair judgment, papers should be submitted under a nom de plume with no information anywhere in the paper regarding the institution or clinic where the work was done. Along with the paper by "John Smith" for example, a plain sealed envelope bearing the nom de plume and the full name and address of the author should also be submitted. Only after all the papers have been judged and returned to the chairman are the sealed envelopes opened and the winners known.

Competition in this contest is open to scientists generally, not necessarily to physicians. The essays are judged on the following considerations: (i) originality of ideas; (ii) potential importance of the work; (iii) experimental methods and use of controls; (iv) evaluation of results; (v) clarity of presentation. This contest is planned as an annual one, but if in any year no paper is considered worthy of a prize, the award may be omitted.

The results will be announced prior to 1 Jan. 1956, and papers not winning a prize become the authors' property and will be returned promptly. Any paper that wins a prize becomes the property of the American Dermatological Association.

The candidate winning first prize may be invited to present his paper before the annual meeting of the American Dermatological Association with expenses paid in addition to the $500 prize. Further information regarding this essay contest may be obtained by writing to the secretary of the American Dermatological Association.

In the Laboratories

■ Two Norelco X-ray Diffraction Schools will be sponsored by the Research and Control Instruments Division, North American Philips Co., Inc., 750 South Fulton Ave., Mount Vernon, N.Y., during the coming months. The 21st weeklong series of sessions will be held at the Sir Francis Drake Hotel, San Francisco, 26–30 Sept., and the 22nd series is to take place at the Hotel Knickerbocker, Chicago, Ill., 10–14 Oct.

Morning sessions will be devoted to lectures, and afternoon meetings will involve powder camera techniques, the x-ray diffractometer (diffraction goniometer), and the x-ray spectrograph (fluorescence analysis).

On Friday the schools will devote the day to actual application problems from the field, and a number of speakers will discuss details and methods in use in industrial plants and laboratories. No registration fee is charged, and those who wish to attend are urged to register as soon as possible, since accommodations will be limited.

■ At least half of 200 large companies engaged in research and development—all of them in essential industries—report shortages of research scientists and engineers, according to Alan T. Waterman, director of the National Science Foundation. On 6 June Waterman made

public the preliminary findings of a study of industrial research being made by the Bureau of Labor Statistics as part of the foundation's national survey of scientific research and development. He described the survey to the 6th Annual Conference on Industrial Research held by the Department of Industrial and Management Engineering of Columbia University in Harriman, N.Y.

Waterman said that the 200 companies interviewed in the study employ a substantial proportion of all scientists and engineers engaged in industrial research. About two-thirds of the companies with shortages reported that the shortages were major. All companies agreed that there is need for better qualified, more highly trained scientists and engineers. A sizable number of firms said that they had been forced to curtail projected increases in their research and development programs because of lack of qualified personnel.

■ De Beers Consolidated Mines has found a 572¼-carat diamond in its Jagersfontein mine near Kimberley, South Africa. This is the third largest ever found at this mine; the largest was the 971-carat Excelsior diamond, discovered in 1893. The Cullinan diamond, found at the Premier mine, weighed 3024¾ carats.

The company said that the latest find was "rather disappointing in that its color is not good and there are a number of spots and cracks, and its quality is therefore not of a high standard." The stone was found by a native. It is 1 in. thick, 2 in. long, and 1¾ in. wide.

■ An 80-year-old engine, one of the few of its kind in existence, has been restored at the Cooper-Bessemer Corp., Mount Vernon, Ohio. The 7000-lb, 15-hp engine that was used for threshing was built about 1875 by the firm's predecessor, the C. & G. Cooper Co. Cooper-Bessemer plans to build a museum in the near future.

■ The Rensselaer Polytechnic Institute library has been designated by the U.S. Atomic Energy Commission as an information depository for atomic data to serve northeastern New York and adjacent New England areas. More than 12,000 nonclassified documents are on file in the library, and additional material is being received each week.

As a part of Rensselaer's services-to-industry program, the atomic data will be available to industrial firms and individuals, who formerly have had to contact the AEC Technical Information Service in Oak Ridge, Tenn., in order to obtain information.

The documents, which include data from Atomic Energy of Canada, Ltd., and the Atomic Energy Research Establishment of Great Britain, are on file in bound pamphlets and on microprint cards.

New Journals

Endocrinologia Japonica, vol. 1, No. 1, Sept. 1954. (In English.) Yosoji Ito, Ed. Endocrinological Society of Japan (Eastern Branch), Institute of Physiological Chemistry, Department of Pharmacy, Faculty of Medicine, Tokyo University, Motofuji, Bunkyo-ku, Tokyo, Japan. Quarterly. $6 per year (except for vol. 1, 2 issues, $3.)

Journal of Inorganic & Nuclear Chemistry, vol. 1, Nos. 1/2, Mar. 1955. (In English, French, and German.) Joseph J. Katz, H. C. Longuet-Higgins, and H. A. C. McKay, Eds. Pergamon Press, Maxwell House, Marleybone Road, London, N.W.1, England; 122 E. 55 St., New York 22. Issued in parts. $12.60 per vol. ($9.80 for individual subscribers' private use.)

Journal of the Japanese Obstetrical & Gynecological Society (English Edition), vol. 1, No. 1, Jan. 1954. The Society, 5, 2-Chome, Kanda-Surugadai, Chiyoda-ku, Tokyo, Japan. Quarterly.

Journal of the West African Science Association, vol. 1, No. 1, Oct. 1954. (In English, French, and German.) A. S. Boughey, Ed. The Association, University College, Achimota, Gold Coast, West Africa. Annually. 21s per year.

Land Locomotion Bulletin, No. 1, Jan.–Apr. 1955. Land Locomotion Division, Detroit Arsenal, Center Line, Mich.

Mineralogical Journal, vol. 1. No. 3, Oct. 1954. Nobuo Katayama, Ed. Mineralogical Society of Japan, Department of Geology and Mineralogy, Faculty of Science, Hokkaido University, Sapporo, Japan. $1 per issue.

Veterinary Reviews and Annotations, vol. 1, Pt. 1, Apr. 1955. W. A. Pool, Ed. Commonwealth Agricultural Bureaux, Farnham House, Farnham Royal, Nr. Slough, Bucks, England. Semiannually. 25s. per year.

Virology, vol. 1, No. 1, May 1955. George K. Hirst, Ed. Academic Press Inc., 125 E. 23 St., New York 10. $9 for vol. 1.

Miscellaneous

■ The symposium on air pollution that was held at the Berkeley meeting of the AAAS is sumarized in "Some scientific aspects of the urban air pollution problem" by Lauren B. Hitchcock and Helen G. Marcus in the July issue of *The Scientific Monthly*. Other articles in this issue include "Human background of Pacific science," Alexander Spoehr; "Significant scientific discoveries by medical students," William C. Gibson; "An orientation toward modern physical theory," Marshall J. Walker; and "City neighborhood and village," Richard Neutra. Fourteen books are reviewed in this issue.

■ A comprehensive exhibit on the peaceful uses of atomic energy has been sent to Latin America for presentation to audiences in the Central and South American countries as part of the U.S. Overseas Information Program. The display consists of a series of panels and three reactor models describing present and proposed applications of nuclear energy. Loan of the reactor models was arranged through the Atomic Industrial Forum, Inc.

■ Applications are invited by the council of the Indian Institute of Science for the post of the director of the institute. Essential qualifications for the position are high scientific attainment, administrative ability, and experience. The salary will range from R. 2000 to R. 2500 per month ($400–$500), depending on the qualifications of the candidate.

The person selected will be on probation for a period of 2 years, after which, if confirmed, he will continue until his retirement at the age of 60. He will be a member of the institute's Provident Fund Scheme, for which the subscription rate is between 1½ and 2½ annas per rupee; the institute contributes an amount equal to 8 1/3 percent of the salary. Leave and other privileges will be determined by the regulations and bylaws. An unfurnished house situated on the institute grounds will be provided, and rent and other charges will be levied as prescribed.

The appointee is entitled to a one-way travel fare if he is single, or two fares if he is married. For further information and forms, write to the registrar, A. G. Pai, Indian Institute of Science, Bangalore 3, India. *Completed applications must be received by 5 Sept.*

■ At the 44th annual meeting of the International Association of Medical Museums held in Houston, Tex., 5–6 Apr., the name of the association was changed to the International Academy of Pathology. Ever since its organization in 1906, the association has been primarily interested in advancing the teaching of pathology, and it was felt that this change in name would more adequately identify the association's main objective. The association currently has about 800 members consisting chiefly of pathologists.

The next meeting of the association will be held in Cincinnati on 24–25 Apr. 1956. For information, write to the secretary-treasurer, F. K. Mostofi, Armed Forces Institute of Pathology, Washington 25, D.C.

Reports and Letters

Human Amnion Cells for Large-Scale Production of Polio Virus

We wish to report a readily available source of large amounts of normal human cells that can be grown in mass tissue cultures and that support propagation of poliomyelitis virus. Large numbers of human placentae and membranes can be obtained in this country because of the many deliveries in clinics and hospitals. The high content of blood in the placentae and hyaluronic acid in the umbilical cord made it difficult to culture these tissues on a large scale. We have found, however, that the amnion and chorion lend themselves easily to washing, cutting, trypsin digestion, and growth in tissue culture.

The membranes from one delivery yield approximately the same quantity of cells as the kidneys of one monkey. Although Enders (*1*) has reported that cells emerging from fragments of amniotic membrane (2- or 3-mo gestation) are destroyed by poliomyelitis virus, this is not a suitable source of cells for routine culturing. We have found that cells of the full-term amnion support the growth of poliomyelitis virus and that the virus production is about the same as that in monkey kidney cells, which are currently being used to produce poliomyelitis virus for vaccine production.

In the present work (*2*) the two membranes were cut from the placenta and dropped into a phosphate-buffer solution at *p*H 7.2 containing penicillin and streptomycin. The amnion was stripped from the chorion, and each tissue was prepared separately. They were washed repeatedly in fresh changes of phosphate-buffer solution, and the chorion was gently scraped to remove the small blood vessels and clotted blood; this was not necessary for the amnion. The tissue was cut into pieces approximately 2 cm square and stirred gently in a 0.25 percent trypsin-buffer solution. The liberated cells were decanted at 20-min intervals, centrifuged at low speed, washed twice, and diluted with the culture medium. Plates, tubes, and flasks were seeded with cells from each tissue and with a mixture of cells from both. Although the membranes were usually worked up within 5 hr after delivery, it seems probable that they could be stored for longer periods of time without injury to the cells.

The cells of primary and secondary cultures grew equally well in media containing homologous or heterologous serums: cord, human, horse, ox, lamb. At a level of 20 percent, the serum yielded better growth than it did at a level of 40 percent. The medium for large-scale culturing consisted of 20-percent ox serum in either Parker's 199 or Earle's balanced salt solution containing 0.5 percent lactalbumin hydrolysate. Embryo extract gave no additional response and was omitted.

A cytologic preparation of the amniotic membrane, stained with Heidenhain's hematoxylin, showed a uniform layer of cuboidal, ectodermal cells. These were occasionally interlaced with much larger cells that stained less intensely. In tissue culture, the cells were uniformly epithelial, with two groups of cell sizes. The smaller cells were more numerous, and each flattened to cover an area of approximately 4 to 10 μ^2. The cytpolasm appeared homogeneous with few granules or vacuoles. The larger cells, which varied in number from preparation to preparation, each covered an area of 20 to 60 μ^2. They assumed bizarre forms and had prominent, parallel fibrous structures in their cytoplasm. The chorion consisted of a mixture of epithelial and fibroblastic cells. It yielded a heterogeneous population of cell types in tissue culture that was in contrast to the uniformly epithelial cells from the amnion. To date, successful preparations have been obtained from the membranes of 10 deliveries.

The amniotic cells were capable of infection with poliomyelitis virus, type I (Mahoney), type II (MEF-1), and type III (Saukett), and both the large and small cells underwent radical cytologic changes. The amount of virus produced by the cultures, measured as plaque-forming-units on monkey kidney plates (*3*), was the same order of magnitude as is usually obtained from cultures of monkey kidney cells. The susceptibility of chorionic cells to poliomyelitis virus infection is being determined, and further work is in progress on nutrition, cytology, the cytopathogenic effects of virus infection, and viral production in the cells from both membranes.

The results (*4*) indicate that human amniotic cells may provide a suitable alternative to monkey kidney cells for the large-scale production of poliomyelitis virus. The incidence of hepatitis or other extraneous viruses in such cell preparations must be determined, and adequate precautions must be taken to avoid complications caused by the possible presence of such viruses. The advantages of human, normal, nonorgan cells and their ready availability are obvious.

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References and Notes

1. J. F. Enders, *Ann. Rev. Microbiol.* **8**, 480 (1954).
2. This investigation was supported in part by a grant from the U.S. Public Health Service, National Institutes of Health, to P. L. Kirk and in part by grants to W. M. Stanley from the American Cancer Society, the Rockefeller Foundation, and Lederle Laboratories, Pearl River, N.Y. We wish to express our appreciation to A. W. Makepeace for providing the membranes and to Rosemary O. Lund for her technical assistance.
3. R. Dulbecco, *Proc. Natl. Acad. Sci. U.S.* **38**, 747 (1952); R. Dulbecco and M. Vogt, *J. Exptl. Med.* **99**, 167 (1954).
4. Edwin H. Lennette and H. H. Welsh of the Viral and Rickettsial Disease Laboratory of the California State Department of Public Health, to whom our preliminary results were communicated, have informed us that they have confirmed the ready growth of the amniotic cells and their infection with poliomyelitis virus.

3 June 1955

Extirpation of Roach Prothoracic Glands

In view of the recent observations on the extirpation of roach prothoracic glands by Chadwick (*1*), it is pertinent to report an almost identical, but shorter, series of experiments carried out in 1950–51 on *Blatta, Periplaneta,* and *Cryptocercus.* These operations, along with many others of an exploratory nature, were directed toward determining the role of the host-roach, *Cryptocercus punctulatus,* in producing the sexual cycles of its symbiotic flagellates (*2*). The cycles take place at the time of molting and have recently been correlated in chart form with the host molting period.

The technique employed here differed from that described by Chadwick only in the addition of a preliminary step that was designed to delimit these elusive glands. Each roach was given a small thoracic injection of 0.2-percent methylene blue in saline about 1 hr before the operation. The four ends of the X-shaped gland were then generally visible through the membranous ventral integument.

The results of these extirpations compare favorably with those of Chadwick and are summarized in Table 1. The total of nymphal roaches was made up of one *Blatta orientalis,* 13 *Cryptocercus,*

and 30 *Periplaneta americana*. A few additional animals that survived no longer than 4 days are omitted, since they never fully recovered from the operation. Of the 37 animals, 10 underwent two postoperative molts, and six underwent three such molts. Although only five individuals reached the adult stage in the first postoperative molt, 18 reached this stage at subsequent molts.

Twenty-one of the *Periplaneta* nymphs were operated on at varying times from a few minutes to 35 days after the molt. Those operated on more than 10 days postmolt had about 60-percent longer first postoperative instars. From this it might appear that the intermolt period had been significantly lengthened by prothoracic gland extirpation; however, it seems more reasonable to conclude that this postoperative instar extension resulted from the operation itself and the subsequent wound repair. The second and third postoperative instars of 16 and six roaches, respectively, were not unduly long. The intermolt periods of many domestic roaches, even among litter mates reared under controlled conditions, are highly variable (*3*). Because of this and the small number of individuals involved in these experiments, speculation on apparent delay in molting is not justified. The sexual cycles of the *Cryptocercus* protozoans were not affected by the extirpations.

In most cases, examination of the excised gland and subsequent autopsy showed a partial removal of 50 to 98 percent of the gland. In the cases in which 98 percent or more was removed, it could not be determined with absolute certainty by either of these methods whether a small part of one or more ends was left within the animal. Further, the gland frequently forms small branches along fine tracheae. The ease with which these were torn away left some question concerning the possibility of complete removal and consequent reliability of the operation. Although no significant regeneration was noted, it was felt that very small sections of the gland might be sufficient to enable an animal to continue its growth and development. At the time of these operations, and in the light of Bodenstein's findings (*4*), additional experimentation was deemed necessary before publication of these results. The need for further study of this gland, the brain, and perhaps even unsuspected hormone sources, is becoming increasingly apparent. This report is intended as an added stimulus to this end.

Table 1. Prothoracic gland extirpations: molting in the first postoperative instar

Extirpation (%)	Total	Died	Molted to adults	Molted to nymphs	% molting
98 or more	5	0	0	5	100
50 to 98	39	7	5	27	82

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References and Notes

1. L. E. Chadwick, *Science* **121**, 435 (1955).
2. This work was supported in part by a National Science Foundation grant.
3. G. E. Gould and H. O. Deay, *Purdue Univ. Agr. Expt. Sta. Bull.* 451 (1940).
4. D. Bodenstein, *J. Exptl. Zool.* **123**, 413 (1953).

6 April 1955

Doverite, a New Yttrium Mineral

Doverite, a new yttrium fluocarbonate, has been discovered at the Scrub Oaks iron mine at Dover, Morris County, New Jersey. The mineral is named for the city of Dover. It was discovered during the course of work being undertaken by the U.S. Geological Survey on behalf of the division of research of the U.S. Atomic Energy Commission.

The new mineral occurs in aggregates mixed with xenotime, hematite, and quartz. The aggregates are irregular—some of them are as large as 1 in. in diameter, and some of them have rims of bastnaesite.

In parts of the mine, doverite constitutes several percent of the gangue. It is anisotropic and has indices of refraction in the range from 1.700 to 1.685. No detailed optical data can be presented because of the finely crystalline nature of the mineral. The marked similarity of the x-ray diffraction powder patterns of doverite and synchisite ($CeFCO_3 \cdot CaCO_3$) indicates that the minerals are in the same crystal system and have the same crystal structure. The three strongest lines of doverite are 9.7, 3.53, and 2.78 A, which are almost identical with those of synchisite 9.7, 3.56, and 2.80 A.

Doverite is very fine grained and physically inseparable from the other components of the aggregates. Hematite and doverite were leached from the aggregates with concentrated hydrochloric acid; a residue of quartz and xenotime was left. Interpretation of chemical analyses of the aggregates shows doverite to be an yttrium analog of synchisite with the general formula $YFCO_3 \cdot CaCO_3$, the Y in the formula including several elements of the rare-earth group.

Doverite is brownish red and constitutes the bulk of the aggregates, which have a nonmetallic luster and a brownish streak, are brittle, and break with an uneven to subconchoidal fracture. Their hardness is 6.5, and the specific gravity is 3.89.

Chemical analysis of the aggregates shows the following percentages: rare-earth oxides, 44.36 (including Ce_2O_3 7.40); ThO_2, 1.62; SiO_2, 9.70; Fe_2O_3, 8.90; CaO, 9.80; P_2O_5, 8.75; Al_2O_3, 0.54; UO_3, 0.22; TiO_2, 0.75; MgO, 0.53; total H_2O, 1.35; CO_2, 11.75; and F, 2.87; total 101.14; less O = F 1.21; total, 99.93. Spectrographic analysis by K. E. Valentine of the Geological Survey shows Y to be a major component. The rare-earth components include minor amounts of Ca, La, Gd, and traces of Dy, Er, Yb, Nd, Pr, Lu, Ho, Tm, and Eu. Further detailed work on the minerals of this deposit is in progress.

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29 April 1955

Orientation of Single-Crystal Silver Halides by Epitaxy

Attempts to orient single-crystal boules of AgCl and AgBr grown from the melt have been rather unsuccessful. These boules have the shape of cylinders and show no crystal faces. Orientation of the boules has been tried by (i) cleavage, (ii) punch figures, (iii) x-rays, and (iv) etch figures. Attempts to develop cleavage by striking a boule cooled in liquid nitrogen were not uniformly successful. These silver halides do not respond to the punch-figure technique of orientation because their glide elements $\langle 110 \rangle \{1\bar{1}0\}$ do not lead to prismatic slip. Our attempts to have the boules oriented by x-rays have not been successful, probably because of the high x-ray absorption of these salts. Further, the x-ray method does not readily give information on whether or not the boule is a single crystal. Etching with 10 percent $Na_2S_2O_3$ solution will reveal the grain boundaries in a boule consisting of more than one crystal but does not reveal the orientation.

Boules of AgCl and AgBr can be readily oriented by epitaxy of NaCl on the boule surface. This epitaxy (parallel oriented growth of NaCl on the silver halide) is produced by completely immersing the boule in a water solution of NaCl (saturated at room temperature) and allowing the solution to evaporate slowly in a constant-temperature room. After the solution has evaporated for several days, the boule acquires a coating of fine NaCl cubes (0.1 mm to 2.0 mm in size) in a close parallel-growth arrangement. The orientation of any portion of the boule can be readily seen from the integrated reflections from the (100) faces of these small cubes and can be accu-

rately oriented by suitable optical methods. In addition, the epitaxy will confirm or deny the single crystal character of the boule. If the boule consists of more than one crystal, the grain boundary is easily delineated by the discontinuity in reflections from the cube face. Thus, in the case of recrystallized sheet AgCl wherein the grains are 1 cm or more in size the epitaxy of NaCl on the sheet consists of polygonal areas of commonly oriented cubes so that an orientation can be assigned to each grain. In the case of a cylindrical or hemispherical surface of a single crystal the epitaxy is observed to be complete—that is, valid for all orientations of the silver halide surface.

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30 March 1955

Spectrophotofluorometric Assay in the Visible and Ultraviolet

With the commercial instruments now available, fluorescence assay has been applied to many compounds that are visibly fluorescent. This paper (*1*) describes an experimental instrument that extends the scope of fluorescence analysis to permit the excitation of compounds and the measurement of the resulting fluorescence throughout the ultraviolet and visible regions. The instrument, which we call a *spectrophotofluorometer,* has been applied to a number of problems involving both identification and quantitative assay of organic compounds. Data obtained with indoles and 5-hydroxyindoles illustrate the usefulness of the instrument.

The apparatus (Fig. 1) consists of a 125-watt xenon arc to provide uniform

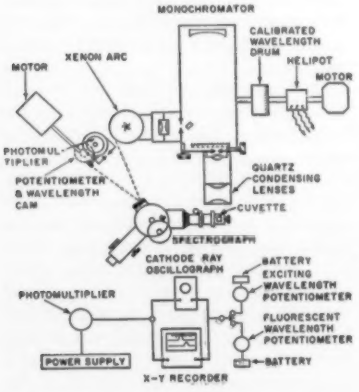

Fig 1. Schematic arrangement of spectrophotofluorometer and block diagram of electric components.

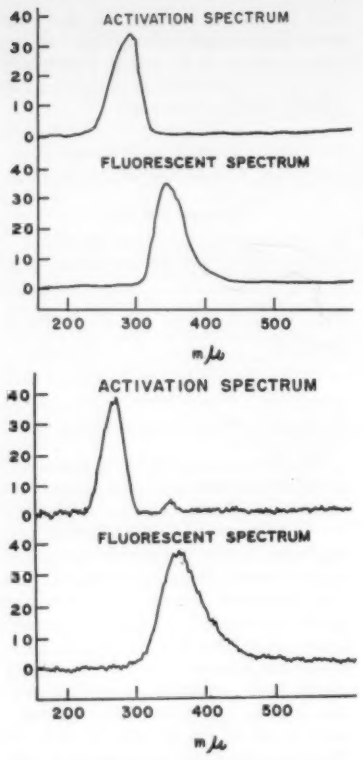

Fig. 2. Activation and fluorescence spectrums of tryptophan (top) and 5-hydroxytryptamine (bottom). The units on the ordinates are arbitrary.

light output from the ultraviolet through the visible, together with a Bausch and Lomb grating monochromator to select the activation wavelength. The sample, about 1 ml, is placed in a 1-cm² silica cuvette. The fluorescent light is analyzed by passing it through a modified quartz prism microspectrograph equipped with a mechanical scanning device containing an ultraviolet-sensitive photomultiplier type 1P28. The photomultiplier output is coupled to the vertical axis of a cathode-ray oscilloscope, and the output of a potentiometer coupled to the wavelength cam is applied to the horizontal axis.

In operation, the phototube scanning the emitted fluorescent light plots a wavelength versus intensity diagram on a Du Mont type 304H cathode-ray oscilloscope. This is designated as the fluorescence spectrum. The same signal may also be supplied to a pen-and-ink recorder or to a galvanometer. A wavelength information signal is also provided on the input monochromator so that when the fluorescence analyzer is set to the wavelength of the peak output, the incident wavelength can be varied through the visible and ultraviolet. Fluorescence intensity plotted against the wavelength of the activating light yields a curve designated as the activation spectrum. The wavelength of the exciting light is determined from the calibrated monochromator dial standardized against the lines of a mercury arc. The location of the maximums in the curves presented in Fig. 2 are accurate to ±5 mμ, but their shapes are slightly deformed as a result of several minor optical defects.

Activation and fluorescence spectrums of tryptophan and 5-hydroxytryptamine (serotonin) are presented in Fig. 2 (*2*). These spectrums are typical of those of other indoles and 5-hydroxyindoles. Over the range of *p*H from 2 to 11, 5-hydroxyindoles are maximally activated at 295 mμ and fluoresce at 330 mμ, whereas indoles are activated at 275 mμ and fluoresce at 360 mμ. All the indole and

Table 1. Activation and fluorescence maximums of some organic compounds.

Compound	Medium	Activation (mμ)	Fluorescence (mμ)
Tryptamine	*p*H 2–11	275	360
Tryptophan	*p*H 2–11	275	360
Indoleacetic acid	*p*H 2–11	275	360
Indole	*p*H 2–11	275	360
5-Hydroxytryptamine	*p*H 2–11	295	330
5-Hydroxytryptophan	*p*H 2–11	295	330
5-Hydroxyindoleacetic acid	*p*H 2–11	295	330
Epinephrine	0.01*N* H_2SO_4	275	320
Norepinephrine	0.01*N* H_2SO_4	275	320
Dihydroxyphenylalanine	0.01*N* H_2SO_4	275	320
Tyrosine	0.01*N* H_2SO_4	270	300–330
Morphine	0.01*N* H_2SO_4	270–290	365
o-Aminophenol	4*N* H_2SO_4	265	310
m-Aminophenol	4*N* H_2SO_4	265	310
p-Aminophenol	*p*H 8	295	365–370
o-Hydroxybenzoic acid	*p*H 5–6	290	420
m-Hydrobenzoic acid	0.1*N* NaOH	315	420
p-Hydroxybenzoic acid	0.1*N* NaOH	280	330
Aniline	*p*H 9	290	360
Lysergic acid diethylamide	*p*H 9	315	440

5-hydroxyindole compounds examined (Table 1) fluoresce with sufficient intensity that 0.1 to 0.4 μg/ml can be measured. This sensitivity has made it possible to develop a fluorimetric procedure, described elsewhere (*3*), for the determination of 5-hydroxytryptamine in blood. This compound is found in human blood to the extent of about 0.1 to 0.2 μg/ml.

Fluorescence evoked by ultraviolet radiation below 365 mμ is not peculiar to the indole compounds but occurs with a large number of organic compounds. The results of a preliminary survey of organic compounds that show both visible and ultraviolet fluorescence are presented in Table 1.

The instrument described is intended only to provide information about the utility and design of a spectrophotofluorometer. A more practical form of this instrument is currently being designed.

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References and Notes

1. We wish to express our appreciation to Bernard B. Brodie, who was instrumental in getting this study under way.
2. 5-Hydroxytryptamine was made available by Abbott Laboratories and Upjohn Laboratories as the creatinine sulfate complex. 5-Hydroxytryptophan and 5-hydroxyindoleacetic acid were synthesized by A. Ek and B. Witkop. The other indole compounds were commercial samples that were shown to be chromatographically pure.
3. S. Udenfriend, C. T. Clark, H. Weissbach, *J. Biol. Chem.*, in press.

4 April 1955

Priority for Reporting of Scientific Discoveries

Many problems concerning priority for the reporting of scientific discoveries are symptomatic of the fierce competition that often underlies the professional relationships among scientists. Although it can be demonstrated, historically speaking, that many scientific discoveries have been announced by several investigators almost simultaneously or within an exceedingly short period of time (*1*), various individual names are associated with these discoveries, even though the work of others may have been of equal magnitude. On the other hand, many scientists do not even bother to give credit to those who hold priority for scientific ideas; and thus they strive to establish an impression that priority for these ideas belongs to themselves (*2*). Much of this behavior, of course, is concerned with the general emotional problems of scientists in a world where competition for prestige is perhaps even more important than competition for monetary gain (*3*).

From the practical standpoint, nevertheless, the remarks of Lillie (*4*) on the subject of spurious publication dates are of considerable importance. This is especially true in the field of systematics, where priority establishes the name of a new species, genus, and so forth, and thus avoids the chaos that would otherwise result.

With regard to the general question of priority that was discussed by Lillie, we agree that the actual publication date should be clearly defined with regard to priority. As an example, according to the *International Rules of Zoological Nomenclature* the date of publication is the date on which the publication was mailed or placed on sale (*5*). It appears to us that the actual date of mailing (or sale) of the journal issue is a logical basis for appraising priority because it represents the shortest period in time between unavailability of scientific papers and the moment when they begin to exert "influence on the progress of research in other institutions" (*4*).

Lillie also suggests that journals print the date of receipt of a paper, but he does not seem to clarify the reasons for this proposal. Many journals do indicate the dates of receipt, but, as Lillie suggests, these dates generally are ignored. It appears to us that the date of acceptance of a paper has more value than the date of receipt. In some cases these two dates occur close together, but in many others a considerable period intervenes between receipt and acceptance, which may be preceded by several revisions. The date of acceptance might well be considered as the major basis for appraising priority because it constitutes the final act in the chain of scientific "cerebration, instrumentation, manipulation, and interpretation" (*6*).

The problem of assigning priority to a paper published in a journal dated in the year just preceding the year of actual mailing would probably be solved if all journals showed both the actual mailing dates on the particular issues and the dates of acceptance on the particular papers. The date of acceptance would also prevent the assignment of priority to paid papers, which are usually published in the next issue of the journal. A prominent American journal states in its notice to contributors that "accepted papers which raise no questions of scientific priority may however secure earlier publication . . ." if the cost of publication is paid. The danger of this policy lies in the fact that the editorial board cannot know whether a question of priority exists except with regard to its own journal. Thus the date of acceptance becomes vital, for a paid paper may announce a discovery a year or more prior to publication of a similar finding that was in press when the paid paper was accepted. This might discourage rapid publication of paid papers written by unscrupulous or emotionally insecure scientists who have gleaned material either from manuscripts in preparation by colleagues or from those, written by colleagues, that are already in press.

In summary, we propose that journals show both the actual date of mailing of the journal and the date of acceptance of the paper as the basis for priority. Furthermore, these dates should also appear on reprints or tear sheets for distribution by authors. Finally, editors might well require authors to include the mailing date of a journal in bibliographic citations.

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References

1. B. J. Stern, *Social Factors in Medical Progress*, (Columbia Univ. Press, New York, 1927), chapt. 3; W. F. Ogburn and D. Thomas, *Political Sci. Quart.* 37, 83 (1922).
2. M. C. Hall, *Sci. Monthly* 47, 152 (1938).
3. L. S. Kubie, *Am. Scientist* 41, 596 (1953); 42, 104 (1954).
4. R. D. Lillie, *Science* 120, 7A (15 Oct. 1954).
5. E. Mayr, E. G. Linsley, R. L. Usinger, *Methods and Principles of Systematic Zoology*, (McGraw-Hill, New York, 1953), chapt. 11.
6. W. A. Wildhack, *Sciences* 120, 15A (22 Oct. 1954).

14 January 1955

Physical and Chemical Factors in Relation to Histoplasma capsulatum in Soil

The geographic variation in the prevalence of histoplasmin sensitivity is an established epidemiologic fact, but the basis for this phenomenon remains unknown. Undoubtedly the variation results in part from factors that influence the occurrence and distribution of the sensitizing agent, *Histoplasma capsulatum*, in the environment.

The primary source of *H. capsulatum* is believed by most investigators to be soil, but the fungus is not found in all soils. Even within an area of high prevalence of histoplasmin sensitivity such as Williamson County, Tenn., *H. capsulatum* has been isolated with significantly greater frequency from some soils than it has from others (*1, 2*). Studies have demonstrated that the fungus is cultured predominantly from soils in places frequented by chickens, although chickens are not a reservoir of histoplasmosis. It is logical to assume that qualitative or quantitative variations in the chemical components or physical characteristics of different soil specimens may be at

least partially responsible for the presence of the fungus in one sample and its absence in another. It was in an effort to discover any such determining factors that the study reported here was undertaken (*3*).

Mycological studies of soil from Williamson County have been conducted on a survey basis in the past with soil samples collected at random from all parts of the county and from a variety of sources (*1, 2*). In the present investigation it was desired to obtain as high a yield of isolations of *H. capsulatum* as possible. Therefore, most of the soil samples were collected from sites where the fungus had been found previously, and from sources known to harbor the fungus most commonly, such as chicken houses and chicken yards. Thus, a little more than half of the specimens (54 of 100) were obtained from the latter sources, but 46 samples were collected from less likely habitats in order to provide material for comparison.

Soil samples were collected by scraping the top 0.5- to 1-in. layer of soil into a clean, previously unused, wax-lined paper carton of 1-pt capacity. The sample was assigned a number, and a record was kept of the source from which it had been obtained. After the sample had been thoroughly mixed to make it as homogeneous as possible, aliquots were sent to the mycology unit of the Communicable Disease Center in Chamblee, Ga., and to the Georgia Agricultural Experiment Station at Experiment, for mycological and physical-chemical study, respectively. In order to avoid the introduction of bias, neither laboratory was advised of the source of the sample or the results of the other's analysis until all studies had been completed.

The method used for the isolation of *H. capsulatum* from soil has been described previously (*2*). The moisture-holding capacity of the various soil samples and the percentage of clay in them were determined by the methods of Bouyoucos (*4*), with modifications. The methods of Olson (*5*) were used for the analyses of NO_3, P_2O_5, K_2O, CaO, and MgO. Loss on ignition was determined by the procedure recommended by the Association of Official Agricultural Chemists (*6*).

Table 1. Results of mycological examination of 100 selected soil samples by source of sample, Williamson County, Tenn., August 1953.

Samples		*H. capsulatum* isolated	
Source	(No.)	(No.)	(%)
All sources	100	27	27.0
Chicken house	39	18	46.2
Chicken yard	15	3	20.0
Under or near dwelling	38	6	15.8
Other	8	0	

Table 2. Mean values of various physical attributes and chemical components of 100 samples of soil, by source of sample and by presence or absence of *H. capsulatum*, Williamson County, Tenn., August 1953. Values for NO_3, P_2O_5, K_2O, CaO, and MgO are in pounds per acre available; values for loss on ignition, moisture-holding capacity, and clay are percentages.

Test	Normal average medium value	All soils		Chicken house and yard soils		Other soils	
		Pos.	Neg.	Pos.	Neg.	Pos.	Neg.
*p*H		6.2	6.6	6.2	6.6	6.0	6.5
NO_3	15– 30	59.3	51.9	59.3	58.9	59.2	46.6
P_2O_5	100– 150	446.0	461.3	432.0	467.7	500.0	456.3
K_2O	150– 250	539.1	548.8	562.5	614.0	461.2	495.9
CaO	400–1000	2937.9	2881.7	2930.4	2896.8	2966.7	2870.0
MgO	40– 100	182.8	175.7	180.4	176.6	191.7	175.0
Loss on ignition	5– 7	19.4	17.4	21.5	22.3	11.2	13.6
Moisture-holding capacity	20– 30	35.1	34.0	38.9	40.1	31.3	32.2
Clay	15	15.3	19.0	15.4	19.3	15.3	18.9

The physical and chemical analyses are correlated with the mycological findings in Table 2. The values for most of the attributes studied were so uniformly high that small differences became meaningless. The most noteworthy finding was the observation that soils from which *H. capsulatum* had been isolated had an appreciably higher acidity than negative soils. In addition, it was noted that among positive soils, those that had been obtained from chicken houses and yards had a significantly higher organic carbon content and moisture-holding capacity than positive soils from other sources. These observations are not unexpected, of course, for soils associated with chickens are heavily contaminated with manure and thus are rich in organic matter, and the high humus content of the soil tends to increase its capacity to hold moisture.

The higher acidity observed in soils positive for *H. capsulatum* suggests that the *p*H may be an important factor in determining whether a particular specimen of soil would make a good or poor habitat for the fungus. In the laboratory *H. capsulatum* is capable of abundant growth over a wide range of *p*H. Under natural conditions, however, when the fungus is competing for survival with myriads of other microorganisms in the soil, the level of *p*H may be more vital. It is possible that acid soil may act by inhibiting certain competitors, rather than by enhancing the growth of the fungus directly. It may be worthy of note that, in areas of highest prevalence of histoplasmin sensitivity, the soil is characteristically acid (*7*).

Histoplasma capsulatum was isolated from 27 of 100 soil samples (Table 1). By far the greatest proportionate yield of the fungus was obtained from specimens collected inside chicken houses, chicken yards, and under dwellings where chickens had congregated. These findings were consistent with the results of previous studies (*1, 2*).

Although the results of these studies do not explain either why there is a geographic variation in the prevalence of histoplasmin sensitivity or the association of *H. capsulatum* in soil with chicken habitats, it is hoped that they will stimulate further investigations.

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References and Notes

1. L. D. Zeidberg *et al.*, *Am. J. Public Health* **42**, 930 (1952).
2. L. D. Zeidberg and L. Ajello, *J. Bacteriol.* **68**, 156 (1954).
3. We gratefully acknowledge the technical assistance in the mycological study of soil of Laliah C. Runyon of the mycology unit, Communicable Disease Center; the aid of L. S. Jones, assistant soil chemist of the Georgia Experiment Station for determining the moisture-holding capacity of the samples and the percentage of clay in them; and the contribution of Sara Lou Hatcher, statistician of the Williamson County Tuberculosis Study, in the statistical analysis of the data. We wish to express our deep regret at the untimely death of L. C. Olson of the Georgia Experiment Station, whose advice in planning this study was invaluable. This study was supported in part by grant E-521 from the Microbiological Institute, National Institutes of Health, U.S. Public Health Service; and in part by a grant from the division of medicine and public health, Rockefeller Foundation.
4. G. J. Bouyoucos, *Soil Sci.* **23**, 343 (1927); **40**, 165 (1935).
5. L. C. Olson, "Soil testing methods of the Georgia Experiment Station, Experiment, unpublished.
6. Association of Official Agricultural Chemists, *Official and Tentative Methods of Analysis* (Washington, D.C., ed. 6, 1945).
7. L. D. Zeidberg, *Am. J. Trop. Med. Hyg.* **3**, 1057 (1954).

21 April 1955

Book Reviews

Textbook of Physics. R. Kronig, Ed. In collaboration with J. de Boer, H. C. Burger, P. H. van Cittert, C. J. Gorter, A. C. S. van Heel, P. van der Leeden, and G. J. Sizoo, with biographical notes and tables by J. Korringa. Interscience, New York; Pergamon, London, 1954. xiv + 855 pp. Illus. $10.

The original edition of this book was written during World War II to satisfy the need for a textbook in the Dutch language that would cover the entire field of physics. Since the book was the result of the combined efforts of outstanding men in creative research, it is not surprising that it was an exceptionally clear, concise, and accurate exposition of undergraduate physics. The book was received enthusiastically, a third printing was necessary after only 4 years, and the authors were therefore encouraged to prepare an English translation. This comprehensive survey of physics has thus become available to a much larger number of students.

Textbook of Physics is divided into 12 principal sections and concludes with 30 pages of interesting biographical notes and a table of natural constants, both prepared by Korringa. The first five sections present the phenomenological parts of physics. The introduction (22 pp.) by Kronig contains a brief, well-written summary of the mathematical tools of physics. The section on mechanics (113 pp.) by Van der Leeden covers the conventional material on dynamics of particles and rigid bodies in a rigorous condensed treatment (63 pp.). The remainder is allocated about equally to gravitation, elasticity, and fluids. The following section on vibration and waves (51 pp.) by the same author is about evenly divided between the theory of vibration and the mechanism of wave propagation. Several topics of this section, such as forced vibrations of a damped system and group velocity in wave propagation, are more advanced in nature and, hence, are presented in small type.

The fourth section on electrodynamics (153 pp.) by Sizoo is an excellent treatment beginning with the simple concepts of charge, current, and voltage, and leading logically into the more advanced concepts of electric and magnetic fields, alternating currents, electromagnetic waves, and theory of relativity. A summary, which compares the formulas for the electric field with those for the magnetic field, at the end of the section has especially great pedagogic value. The fifth section on physical optics (88 pp.) by Van Cittert is a fairly standard treatment of interference, diffraction, and polarization phenomena.

The next three sections present the atomistic parts of physics. Section six on atomic structure (50 pp.) by Kronig discusses cathode rays, radioactivity, Bohr's postulates (but not Bohr theory), light quanta, and matter waves. Line spectra, x-ray spectra, and band spectra are introduced in a logical fashion by a short discussion of quantum mechanics. The treatment of the interaction between radiation and atoms (4 pp.) and nuclear physics (5 pp.) are unfortunately brief. Section seven on atomic theory of heat (70 pp.) by de Boer covers kinetic theory (*including transport phenomena*), crystal structure, specific heat of solids, and the theory of radiation. Section eight on atomic electricity (45 pp.) by Gorter is principally a short account of electric conduction in solids, liquids, and gases. Several topics in solid-state physics (dielectric polarization, semiconductors, and magnetic properties of solids) are discussed but all too briefly. Less than two pages is devoted to semiconductors.

The last four sections are appropriately placed at the end of the book in order to avoid disturbing the continuity of the major portion. Section nine on thermodynamics (74 pp.) by de Boer covers much of the standard material given in an introductory course in the subject. Section ten on electric instruments (35 pp.) by Gorter and section eleven on optical instruments (68 pp.) by Van Heel are particularly valuable as reference material. The final section on medical physics (41 pp.), by Burger is something really new in a textbook of this sort and is therefore particularly welcome, especially to students in biology or biophysics.

As a textbook this volume is impressive in many respects. The subjects are treated so rigorously and coherently that a student will not have to unlearn any material if he continues his studies in physics. It is beautifully printed. Typographic errors are practically nonexistent. The rationalized mks system is used exclusively throughout the book. The principal weakness from a teacher's point of view is the complete absence of problems and the almost complete absence of illustrative numerical examples.

Textbook of Physics has many excellent features that make it an outstanding reference work as well as a textbook. In particular, one might mention the numerous more advanced topics printed in small type, the many subjects of specialized interest marked by asterisks, the lists of books recommended for further study (at the end of each section), and the biographical material. It would indeed be a valuable addition to the bookshelf of any serious student of science.

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Modern Aspects of Electrochemistry. J. O'M. Bockris, Ed. With the assistance of B. E. Conway. "Modern Aspects Series of Chemistry," No. 1. F. C. Tompkins, Ed. Academic Press, New York; Butterworths, London, 1954. x + 344 pp. Illus. $6.80.

This is the first of a series of books to be published on the modern aspects of chemistry, and it deals with five topics in the field of electrochemistry. It is hoped that this book will not be the sole one in electrochemistry. Although the topics, discussed by experts in the fields, are well done and timely, they cover a restricted area in electrochemistry.

The editors have compiled an interesting reference book, which should prove valuable to the specialist and to those with fundamental backgrounds but not actively engaged in electrochemistry. The topics, are presented somewhat in the nature of reviews in five chapters: "Physical chemistry of synthetic polyelectrolytes," H. Eisenberg and R. M. Fuoss; "Ionic solvation," B. E. Conway and J. O'M. Bockris; "Equilibrium properties of electrified interphases," R. Parsons; "Electrode kinetics," J. O'M. Bockris; and "Electrochemical properties of nerve and muscle," W. F. Floyd.

Eisenberg and Fuoss give a good discourse for the expert on the modern advances made in the physical chemistry of synthetic polyelectrolytes. Although it contains much that is electrochemistry, it includes discussions, undoubtedly essential, on the structure of polyelectrolytes as found from colligative, surface, and hydrodynamic properties, and in this sense deviates from Bockris' definition of electrochemistry as given in his preface.

Conway and Bockris emphasize once again the difficulties encountered in obtaining unequivocal values for the degree of solvation of ions and discuss at

length the various methods used to obtain hydration numbers and the reasons the various methods do not give concordant results. They appear to accept the thesis of "primary" and "secondary" solvation and the concept that values of "secondary solvation" are dependent on the method used in their determination.

Parsons gives an outline of recent attempts to evaluate the electric potential of interfaces, devoting a large portion to the concepts of Lange. Parsons clearly points out wherein various theories fail to represent experimental observations and where necessary evidence for a hypothesis is lacking.

Bockris, in a systematic manner, outlines recent concepts regarding the kinetics of electrode reactions. His chapter is highly mathematical. He presents, in an interesting way, modern aspects on polyelectrodes, sonic electrode kinetics, and photo-electrode kinetics.

Floyd presents a most enjoyable discussion of the electrochemistry of nerves and muscles. His chapter can be followed readily by those not engaged in electrophysiology. It is well illustrated and gives emphasis to chemical aspects.

An extensive bibliography is included with each chapter. Most readers will find this book well worth while. It should be read by those who are engaged in or who contemplate work in electrochemistry.

WALTER J. HAMER
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La Cybernétique. Du cerveau humain aux cerveaux artificiels. Paul Cossa. Collection, Evolution des Sciences. Masson, Paris, 1955. 98 pp. Illus. Paper, F. 525.

This little book, by a neurologist, is written in a sprightly and popular style and betrays no indications that the author is the least bit overawed by the claims of enthusiastic cyberneticists. Its nine chapters touch on the origin of cybernetics (following the introduction of Wiener's *Cybernetics* and, so, underestimating the contribution of early work in communication engineering, process control industries, and the like), models of vital behavior, feedback, the mechanical "animals" of Grey Walter, Albert Ducrocq, and the homeostat of Ashby (referred to generally as "les petits monstres") electronic calculators (numerical and logical) and translators (dubbed "les grandes monstres"), the information concept and entropy, aspects of the new industrial revolution implied by automation, and finally whether machines can think, learn, or create, and similar metaphysical considerations.

Cossa has done an excellent job of popularization without becoming sloppy in his treatment of concepts that are not always elementary. The only bone I would pick with him concerns the opinions expressed on what machines cannot do. It is no real limitation on machine behavior to say that a machine can do only what its creator designs it to do, for it is not inconsistent with science to view man himself, exhibited by the author as not so limited, as a creature that can do only what his Creator designed him to do! To say that a machine cannot create, perform a critical function, or learn is mere rhetoric without an operational specification of what these words mean. I find it more plausible to believe that (i) what can be specified operationally can be realized in principle in a machine, and (ii) insofar as the mechanistic viewpoint is valid in biology, admitting creativity, and so forth, in man, it implies the same for the machine. Of course, no machine can do these things now, but denial of the possibility of it ever doing so seems unjustifiable.

JEROME ROTHSTEIN
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The Chemistry of Petroleum Hydrocarbons. vol. I. Benjamin T. Brooks, Cecil E. Boord, Stewart S. Kurtz, Jr., and Louis Schmerling, Eds. Reinhold, New York, 1954. viii + 646 pp. Illus. $18.

This volume of *The Chemistry of Petroleum Hydrocarbons* has been written by 60 outstanding chemists who have spent the major portion of their lives in this field. They have concentrated in 646 pages the chemistry of a field of hydrocarbons that bears an intimate relationship to the 8-million-barrels daily production of petroleum which plays such a highly important role in our economic life, our welfare, and the defense of our nation. Many of these experts are in the petroleum industry.

The scope of this volume covers mainly scientific fundamentals. There are 21 chapters: "Hydrocarbons in Natural Gases," by D. T. McRoberts (United Gas Co.) and T. W. Legatski (Phillips Petroleum Co.); "Hydrocarbons in Gasolines, Kerosenes, Gas Oils and Lubricating Oils," by A. N. Sachanen (Socony-Vacuum Oil Co.); "Composition of Petroleum Waxes," by B. T. Brooks (consultant, New York); "Types of Crude Petroleum," by W. A. Cruse (Mellon Institute of Industrial Research); "The Composition of Shale Oils," by H. N. Thorne and J. S. Ball (U.S. Bureau of Mines); "Origin of Petroleums," by B. T. Brooks (consultant, New York); "Extractive and Azeotropic Distillations," by C. S. Carlson (Standard Oil Development Co.); "Separation of Aromatics by Selective Absorption," by A. E. Hirschler (Sun Oil Co.); "Principles of Solvent Extraction," by A. W. Francis and W. H. King (Socony-Vacuum Oil Co.); "Separation of Paraffins by Urea and Thiourea," by R. L. McLaughlin (Mellon Institute of Industrial Research); "Physical Properties and Hydrocarbon Structure," by S. S. Kurtz, Jr. (Sun Oil Co.); "Ultraviolet Spectra of Hydrocarbons," by W. Priestley and B. F. Dudenbostle (Standard Oil Development Co.); "Molecular Structure and Spectroscopic Data," by E. J. Rosenbaum (Sun Oil Co.); "Analytical Applications of Infrared and Raman Spectroscopy," by H. M. Tenney (Esso Standard Oil Co. of Louisiana); "Mass Spectroscopy of Hydrocarbons," by W. S. Young (Atlantic Refining Co.); "Analysis and Composition of the Heavier Petroleum Fractions," by K. Van Nes (Royal Dutch Shell Co., Amsterdam); "Preparation of Pure Paraffins and Olefins," by B. T. Brooks (consultant, New York); "Syntheses of Low Molecular Weight Alicyclic Hydrocarbons," by J. M. Derfer (Ohio State University); "Syntheses of Low Molecular Weight Aromatic Hydrocarbons," by J. M. Derfer (Ohio State University); "Syntheses of High Molecular Weight Hydrocarbons," by R. W. Schiessler and R. L. McLaughlin (Pennsylvania State University); "The Fischer-Tropsch Process," by H. H. Storch (U.S. Bureau of Mines).

After studying this book I have come to the conclusion that no one in the oil industry who has to do with hydrocarbons in oil can afford to be without it. It is a handbook of knowledge on a subject that has been long overdue.

GUSTAV EGLOFF
Universal Oil Products Company

International Review of Cytology. vol. III. G. H. Bourne and J. F. Danielli, Eds. Academic Press, New York, 1954. 530 pp. Illus. $9.50.

Subjects reviewed in this volume include nutrition of animal cells; karyometric studies on cells in tissue culture; properties of urethane and its action on mitosis; composition, and structure of giant chromosomes; chromosomes in mammalian somatic cells; enzymes in isolated nuclei; differential centrifugation of homogenates; enzymatic aspects of embryonic differentiation; azo dye methods in enzymatic histochemistry; transparent chamber methods; the mast cell; elastic tissues; and composition of the nerve cell. All are by outstanding authors—Weymouth, Bucher, Cornman, Alfert, Beatty, Dounce, De Duve and Berthet, Gustafson, Pearse, Williams, As-

boe-Hansen, Dempsey and Lansing, and Brattgard and Hyden.

Especially useful for background information is the review on karyometric studies, since nucleocytoplasmic ratios are becoming increasingly significant to exfoliative cytologists in distinguishing among normal, suspicious, and malignant cells. The enzymes in nuclei and methods for fractionating particulates as obtained from homogenates by differential centrifugation are comprehensively covered. The probable roles of enzymes in embryonic differentiation offer newer slants on the complex problems of development and differentiation in general. The review on giant chromosomes and another on the composition of nerve cells present a valuable survey of these important topics.

Several reviews are illustrated with diagrams or photographs. There is a fairly complete review of the important literature relevant to each topic. The volume carries an author and subject index as well as a table of contents for each article.

Altogether, this and the previous two volumes in the series (1952 and 1953) are beginning to shape up so that in time the essential features of cytology in its broadest sense will be covered. These volumes should be especially helpful to teachers and research workers alike; if for no other reason than that they offer a convenient means for the highly specialized investigators of today to maintain a proper perspective of the manifold problems that are now being attacked from the cellular or subcellular points of view.

M. J. Kopac

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New York University

Principles of Internal Medicine. T. R. Harrison *et al.*, Eds. Blakiston, New York–Toronto, ed. 2, 1954. xxiii + 1703 pp. + index. Illus. + plates. Student 1-vol. ed., $16; professional, 2-vol. ed. boxed, $21. (Order from McGraw-Hill, New York).

This book represents a deliberate attempt to conform with the pattern of education of the modern medical student. The authors feel that the practice of internal medicine should be based on an understanding of preclinical sciences. Hence, the common features of disease, such as pain, headache, fever, shortness of breath, and many others, are adequately discussed from the standpoint of their underlying physiological and biochemical disturbances by a qualified group of contributors. This section of the book presents a challenge to the writers that they have met skillfully, leaving little to be desired.

Since a considerable fraction of the total number of patients seen by an internist have no organic disease, it is important to consider extensively those symptoms that are based on the so-called "functional" disturbances. This is done in a new section devoted to neurological signs of human suffering. Perhaps more attention could be given to discussing the mechanisms by which many and widely differing symptoms can be projected by the patient and in language that appeals more to the busy internist than to the psychiatrist.

An important feature of the book is a chapter that stresses the immediate sympathetic concern that must be shown the patient, in the form of useful measures that can bring relief, before the sometimes elaborate mechanisms of diagnosis can be started.

This book, although geared to the education of the student, will not fail to satisfy the practitioner who will find brief and adequate descriptions of the diseases that represent an assembly of the symptoms and features previously described in fundamental explanations. Treatment becomes obvious. Finally, the index is apparently accurate—a feature not always found in textbooks.

Ralph A. Kinsella

St. Louis, Missouri

Laboratory Techniques in Rabies. Monogr. Ser. No. 23. World Health Organization, Geneva, 1954. 150 pp. Illus. + plate. Paper, $3; cloth, $4. (U.S. distrib., Columbia Univ. Press, New York.)

A project of the WHO Expert Committee on Rabies and the product of 14 distinguished contributors—including Habel, Johnson, Koprowski, and Sellers—this book is truly authoritative. However, it is intended as a manual and not as an exhaustive treatise. The contributors were asked to describe practical and dependable procedures that "could be adapted to the limited facilities and personnel of many rabies laboratories in different parts of the world." The scope embraces the important problem of diagnosis, the production and potency testing of both vaccines and hyperimmune serum, and the breeding and care of laboratory animals.

Many photographs, including an exceptional color plate illustrating the histologic diagnosis of rabies, accompany the usually very clear descriptions. Alternative methods are frequently presented to facilitate adaptation of procedures to local conditions. To this same end, considerable stress has been laid on the rationale underlying the procedures described. Elementary as much of it will seem to the sophisticated reader, this is a book of real importance to those concerned with the operation of public-health laboratories located throughout the world.

John P. Fox

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Inventories of Apparatus and Materials for Teaching Science. vol. III: **Technical Colleges.** pt. 4, **Electrical Engineering.** UNESCO, Paris, 1954. (Distrib. by Columbia Univ. Press, New York.) 147 pp. Paper, $2.75.

This book is one of a series bearing the same title. The other volumes are devoted to different types and levels of educational institutions in which science is taught. All are published as aids to educators whose task it is to rehabilitate schools in war-damaged or underdeveloped areas.

The training of electrical engineers in France, as it is done in Paris at the Ecole Supérieure d'Electricité, is discussed in the first part of the book. A complete inventory of the technical apparatus of the school is presented with the dollar value of each item. To clarify the uses of the apparatus, the curriculum is outlined in great detail. A rather complete picture of the operation of the school is thus available, although it may be somewhat misleading because the importance of, and emphasis given to, various courses is not explained.

In the second part of the book, the corresponding information is presented for the electrical engineering course at the Kungliga Tekniska Högskolan (Royal Institute of Technology), Stockholm.

The third and final part concerns the higher teaching of electricity in Great Britain. This section is extremely brief and is devoted to a general explanation of the educational practices of the country. No inventories are presented and no particular school is used to illustrate these practices.

To those readers for whom the book was intended, its contents will undoubtedly be of great value and interest. Aside from this specific purpose, educators in the electrical engineering field may find some interest in the purposes and methods of other schools. It would seem that the value of the book would have been considerably increased if a wider variety of educational institutions had been discussed.

Lawrence A. Harris

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Proceedings of the Thirty-third Annual Meeting, Highway Research Board. Fred Burggraf and Walter J. Miller, Eds. National Academy of Sciences–National Research Council, Publ. 324, Washington, 1954. xvii + 563 pp. Illus. $8.

This book contains the proceedings of a 4-day conference of the highway technologists of America conducted by the Highway Research Board. The board was organized 11 Nov. 1920 to encourage research and to provide a national clearing house and correlation service for research activities and information on highway administration and technology.

In this volume are 43 of the original 122 research papers and committee reports presented at the annual meeting. Publication reference is given for those papers not in the *Proceedings*. The papers are listed under six major departments covering the entire highway field. These are (i) economics, finance, and administration; (ii) highway design; (iii) materials and construction; (iv) maintenance; (v) traffic and operations; and (vi) soils.

To the highway industry this book represents an important addition to its growing body of scientific knowledge. It is a must for the student of highway engineering and for the practical man who must apply the results of scientific study to highways or other fields with similar problems.

BONNER S. COFFMAN
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Probleme und Beispiele biologischer Regelung. R. Wagner. Georg Thieme, Stuttgart, 1954. v + 219 pp. Illus. DM 29.40 (U.S. distrib., Intercontinental Medical Book, New York.)

Einfuhrung in die biologische Registriertechnik. Herbert Klensch. Georg Thieme, Stuttgart, 1954. x + 222 pp. Illus. DM 33. (U.S. distrib., Intercontinental Medical Book, New York.)

Wagner applies to certain problems of neurophysiology and circulation the point of view of the engineer who is interested in control mechanisms involving feedback. There is little new factual material in this book. Wagner's own experiments, published in 1925, in which he analyzed through action potentials voluntary movements that were performed against friction, inertia, and elastic forces, form the core of the first part. The regulation of the blood pressure through sinoaortic mechanisms and the role of heart reflexes (v. Bezold-Jarisch) are the chief topics of the second part.

The aim of this study, however, was not to reveal new facts but to gain insight into the principal features of regulatory mechanisms that apparently have little in common. In this, the author succeeds in a searching and often brilliant analysis. He shows the significance of the tendon receptors for the regulation of muscle tension and the importance of the muscle spindles for the regulation of height and speed of voluntary contractions. He points out the analogous role of sinoaortic receptors responding to tension and to receptors in the heart responding to stretch for the regulation of blood pressure and the minute volume of the heart, respectively. Central variations in the blood pressure, pupillary reflexes, and other phenomena are analyzed from the same point of view. The book is recommended to anyone interested in an organismically oriented physiology.

Klensch's book gives a well-written and abundantly illustrated introduction to the various laboratory procedures used in current physiological research. It will be useful to others besides the beginner, since it contains a detailed bibliography. The latter, however, is largely restricted to the German literature.

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The Why of Chemistry Problems. Fred B. Eiseman, Jr. Educational Publ., St. Louis, 1954. iv + 303 pp. Illus. $4.50.

In the words of the author: "It is felt that, by working a mathematical problem that requires an exact numerical answer, the student will gain his insight into the principles of chemistry that underlie and are the basis of the solution to the problem. . . . A knowledge of the laws and principles can be acquired by simply memorizing them. However, it should be obvious that meaning, and therefore, understanding, can only accrue to these laws if their application and use can be pointed out, and if the student is required actually to use them in some practical situation." One may acquire the theory of chemistry by reading, but the art of laboratory synthesis and the solution of chemical problems must be acquired by individual performance involving the use of both the mind and the hands.

Subjects included in the various chapters include: how to solve problems; the metric system; significant figures; conservation of mass and energy; atomic weights; gram atomic weights; molecular weights; writing formulas; percentage composition; simplest formula, true formula; balancing equations; weight-weight problems; short-cut in weight-weight problems; excess reactant; the gas laws, use of the gas laws in practical situations; gram molecular volume and specific gravity and density; true formula by using the gram molecular volume; weight-volume problems, vapor density of gases and density and specific gravity of solids and liquids; volume-volume problem; Raoult's law and molality; molarity; equivalent weight; normality; titration problems; equivalent weight and excess reactant; electrochemical equivalent; advanced problems in ionization; problems dealing with specific elements; and writing equations for specific elements.

Each chapter concludes with a set of problems. It is obvious that this book is designed to cover the problem area for any introductory textbook in chemistry; it should serve the objective well, particularly for students who have difficulty with chemistry problems.

The book is recommended for the careful consideration of teachers of introductory chemistry.

ED. F. DEGERING
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Chemical Pathways of Metabolism. vol. I. David M. Greenberg, Ed. Academic Press, New York, 1954. xi + 460 pp. Illus. $11.

This publication probably serves a useful purpose in assembling a great deal of information about the components and mechanisms of the enzymatically catalyzed reactions that comprise the main chemical pathways of metabolism. Volume I consists of eight independent reviews by 10 well-known authors.

Chapter 1, "Free energy and metabolism," illustrates some biochemical applications of the principles that relate free energies and chemical equilibria. Such fundamental material is properly placed at the beginning of a work of this kind, but, perhaps in a revised edition, theoretical principles should be more systematically developed for the benefit of those who lack adequate preparation, or this preparation should be taken for granted so as to permit a more exhaustive review of recent developments in biochemical thermodynamics.

Chapter 2 presents a characteristically stimulating description of the concerted action, effectively implemented in some instances by structural organization, of "Enzymes in metabolic sequences." Chapter 4 skillfully marshals the crucial evidence supporting the most general and important of these reaction sequences, the final common metabolic pathway best known as the "Krebs' cycle."

Of the remaining chapters, three dis-

cuss carbohydrates, one lipids, and one sterols and steroids. Each of them is a comprehensive, well-documented account of current knowledge, organized and presented according to the experience and interests of the authors and the nature of the subject. To do justice to each would require detailed analysis and comparison with other reviews. It may be noted, however, that the title of Chapter 5, "Other pathways of carbohydrate metabolism," scarcely suggests how comprehensively it covers the synthesis, catabolism, and interconversions of most of the naturally occurring sugars. Both this and the chapter on "Sterol and steroid metabolism" are timely, valuable, and illuminating, especially to readers better acquainted with other subjects. Finally, several chapters incorporate extensive comparative biochemical observations.

Many readers will find it convenient to have available a collection of authoritative reviews covering the entire subject of intermediary metabolism. Some may also anticipate that the evident value of the compilation will stimulate the preparation of a unified treatment retaining the vitality and originality of the individual chapters of the present volume.

The technical production of the book is excellent.

JOHN FULLER TAYLOR
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Books Reviewed in The Scientific Monthly, July

The Earth as a Planet, Gerard P. Kuiper, Ed. (Univ. of Chicago Press). Reviewed by B. J. Bok.

Fundamentals of Electrical Engineering, Edward Hughes (Longmans, Green). Reviewed by R. C. Retherford.

Needed Research in Health and Medical Care, Cecil G. Sheps and Eugene E. Taylor (Univ. of North Carolina Press). Reviewed by I. Galdston.

Big Dam Foolishness, Elmer T. Peterson (Devin-Adair). Reviewed by E. F. Bordne.

Proceedings of the First World Conference on Medical Education, Hugh Clegg, Ed. (Oxford Univ. Press). Reviewed by A. Gregg.

The History and Conquest of Common Diseases, Walter R. Bett, Ed. (Univ. of Oklahoma Press). Reviewed by S. Peller.

The Bomb, Survival and You, Fred N. Severud and Anthony F. Merrill (Reinhold). Reviewed by R. J. Hansen.

The Origin of Russia, Henryk Paszkiewicz (Philosophical Library). Reviewed by F. T. Nowak.

The Passenger Pigeon, A. W. Schorger (Univ. of Wisconsin Press). Reviewed by J. S. Wade.

A History of Birds, James Fisher (Houghton Mifflin; Riverside Press). Reviewed by F. A. Pitelka.

Rocket Exploration of the Upper Atmosphere, R. L. F. Boyd and M. J. Seaton, Eds. (Interscience; Pergamon Press). Reviewed by R. B. Penndorf.

Introduction to Modern Algebra and Matrix Theory, Ross A. Beaumont and Richard W. Ball (Rinehart). Reviewed by R. R. Stoll.

Instrumental Methods of Chemical Analysis, Galen W. Ewing (McGraw-Hill). Reviewed by M. G. Mellon.

Hopi Ethics: A Theoretical Analysis, Richard B. Brandt (Univ. of Chicago Press). Reviewed by D. Bidney.

New Books

Capricorn Road. Francois Balsan. Trans. by Pamela Search. Philosophical Library, New York, 1955. 252 pp. $4.75.

Measurement and Evaluation in Psychology and Education. Robert L. Thorndike and Elizabeth Hagen. Wiley, New York; Chapman & Hall, London, 1955. 575 pp. $5.50.

The Story of FAO. Gove Hambidge. Van Nostrand, New York–London, 1955. 303 pp. $6.50.

General Principles of Geology. J. F. Kirkaldy. Philosophical Library, New York, 1955. 327 pp. $6.

Radioisotopes in Biology and Agriculture: Principles and Practice. C. L. Comar. McGraw-Hill, New York–London, 1955. 481 pp. $9.

Petrographic Mineralogy. Ernest E. Wahlstrom. Wiley, New York; Chapman & Hall, London, 1955. 408 pp. $7.75.

Symposium on Atherosclerosis. Publ. 338. National Acad. of Sciences–National Research Council, Washington, 1954. 249 pp. $2.

The Biologic Effects of Tobacco. With emphasis on the clinical and experimental aspects. Ernest L. Wynder, Ed. Little, Brown, Boston, 1955. 215 pp. $4.50.

Tea. A symposium on the pharmacology and the physiologic and psychologic effects of tea. Henry J. Klaunberg, Ed. Biological Sciences Foundation, Washington, D.C., 1955. 64 pp. Paper, $1.

College Physiology. Donald M. Pace and Benjamin W. McCashland. Crowell, New York, 1955. 615 pp. $5.50.

Anxiety and Stress. An interdisciplinary study of a life situation. Harold Basowitz, Harold Persky, Sheldon J. Korchin, and Roy R. Grinker. Blakiston Div., McGraw-Hill, New York–London, 1955. 320 pp. $8.

Studies of Biosynthesis in Escherichia Coli. Publ. 607. R. R. Roberts, P. H. Abelson, D. B. Cowie, E. T. Bolton, and R. J. Britten. Carnegie Institution of Washington, Washington, 1955. 521 pp. Paper, $2.50; cloth, $3.

Embryogenes's in Plants. C. W. Wardlaw. Wiley, New York; Methuen, London, 1955. 381 pp. $7.

The Hunting Wasp. John Crompton. Houghton Mifflin, Boston, 1955. 240 pp. $3.

Gas Dynamics of Cosmic Clouds. A symposium of the International Union of Theoretical and Applied Mechanics and International Astronomical Union. Interscience, New York; North-Holland, Amsterdam, 1955. 247 pp. $5.75.

Some Physiological Aspects and Consequences of Parasitism. William H. Cole, Ed. Rutgers Univ. Press, New Brunswick, N. J., 1955. 90 pp. Paper, $2.

Quantitative Analysis: Methods of Separation and Measurement. M. G. Mellon. Crowell, New York, 1955. 694 pp. $6.50.

Walt Whitman's Concept of the American Common Man. Leadie M. Clark. Philosophical Library, New York, 1955. 178 pp. $3.75.

Breeding Beef Cattle for Unfavorable Environments. A symposium presented at the King Ranch Centennial Conference. Albert O. Rhoad, Ed. Univ. of Texas Press, Austin, 1955. 248 pp. $4.75.

Geology: Principles and Processes. William H. Emmons, George A. Thiel, Clinton R. Stauffer, and Ira S. Allison. McGraw-Hill, New York–London, ed. 4, 1955. 638 pp. $6.50.

Advanced Calculus. Angus E. Taylor. Ginn, Boston, 1955. 786 pp. $8.50.

Practical Laboratory Chemistry. A manual for beginners. Horace G. Deming. Wiley, New York; Chapman & Hall, London, 1955. 209 pp. $3.50.

Culture and Mental Disorders. Joseph W. Eaton. Free Press, Glencoe, Ill., 1955. 254 pp. $4.

Differential Equations. Frederick H. Steen. Ginn, Boston, 1955. 330 pp. $4.

Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History) Described by Edward Meyrick. vol. II. J. F. Gates Clarke. British Museum Natural History, London, 1955. 531 pp. £6.

Stochastic Models for Learning. Robert R. Bush and Frederick Mosteller. Wiley, New York; Chapman & Hall, London, 1955. 365 pp. $9.

Early American Science Needs and Opportunities for Study. Whitfield J. Bell, Jr. Institute of Early American History and Culture, Williamsburg, Va., 1955. 85 pp. $1.25.

Small Boat Owners Guide. Frank C. True. Lantern Press, New York, 1955. 242 pp. $3.50.

Principes fondamentaux de classification stellaire. Colloques Internationaux du Centre National de la Recherche Scientifique. CNRS, Paris, 1955. 188 pp. F. 1200.

Theory of Ordinary Differential Equations. Earl A. Coddington and Norman Levinson. McGraw-Hill, New York–London, 1955. 429 pp. $8.50.

Bird Navigation. Cambridge Monogr. in Exptl. Biol., No. 3. G. V. T. Matthews. Cambridge Univ. Press, New York, 1955. 140 pp. $2.50.

Solar Energy Research. Farrington Daniels and John A. Duffie, Eds. Univ. of Wisconsin Press, Madison, 1955. 290 pp. $4.

Lehrbuch der Praktischen Orthopadie. Ph. Erlacher, Ed. Maudrich, Wien-Bonn, Germany, 1955. 549 pp. $24.50.

Theoretical Structural Metallurgy. A. H. Cottrell. St Martin's Press, New York, ed. 2, 1955. 251 pp. $4.50.

Synthetic Methods of Organic Chemistry. An annual survey. Vol. 9. W. Theilheimer. Karger, Basel; Interscience, New York, 1955. 481 pp. $18.90.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, but to the publisher or agency sponsoring the publication.)

Tree Grades and Economic Maturity for some Appalachian Hardwoods. Sta. Paper No. 53. Robert A. Campbell. Southeastern Forest Expt. Sta., Asheville, N.C., 1955. 22 p.

Point Lobos Reserve. Interpretation of a primitive landscape. Audrey Drury, Ed. Div. of Beaches and Parks, Dept. of Natural Resources, State of California, 1955 (Order from Printing Div. (Documents Section), Sacramento 14, Calif.) 96 pp. $1.

Reserpine in the Treatment of Neuropsychiatric, Neurological, and Related Clinical Problems. Annals of New York Acad. of Sciences, vo. 61, art. 1. Roy Waldo Miner, Ed. The Academy, New York, 1955. 280 pp. $3.50.

Fauna of the Vale and Choza; 10 Trimerorhachic: Including a Revision of Pre-Vale Species. vol. 10, No. 21, Fieldiana: Geology. Everett Claire Olson. Chicago Natural History Museum, Chicago, 1955. 50 pp. $0.85.

The Bupleura (Umbelliferae) of North-West Himalaya. Publ. in Botany, vol. 27, No. 7. Eugene Nasir. Univ. of California Press, Berkeley–Los Angeles, 1955. 28 pp. Illus. $0.50.

Consulting Services. Assoc. of Consulting Chemists and Engineers, New York 17, ed. 15, 1955. 110 pp. $1.

Words for Work. Handbook of trade terms for a tutoring program for new Americans. Jewish Vocational Service, of Greater Boston, Boston, 1955. 140 pp. $1.

Chronicle of the World Health Organization. vol. 9, No. 4, World Health Organization, Geneva, 1955. 28 pp. $0.30.

What You Should Know about Smoking and Drinking. Junior Life Adjustment Booklet. W. W. Bauer and Donald A. Dukelow. 40 pp. 50¢; **What is Popularity?** Mary L. Northway. 47 pp. 50¢; **A Guidance Program for Rural Schools.** Glyn Morris. 48 pp. $1. Science Research Associates, Inc., Chicago 10, 1955.

Handbook on Pests and Diseases. Special printing of *Plants and Gardens,* vol. 11, No. 1. Brooklyn Botanic Garden, Brooklyn 25, 1955. 96 pp. $1.

Les Surfaces derivables relativement a une regle de multiplication (en deux memoires). Maurice Frechet. North-Holland, Amsterdam, 1954. 44 pp.

The Effect of Sugar Supplements on Dental Caries in Children. Special Rpt. Ser. No. 288. J. D. King, May Mellanby, H. H. Stones, and H. N. Green, H.M. Stationery Office, London, 1955. 55 pp.

Transactions of the 19th Annual Meeting and Technical Conferences of Industrial Hygiene Foundation. Held 17–18 Nov. 1954 at Mellon Institute, Pittsburgh. The Foundation, Pittsburgh, 1955. 241 pp. $5.

Yearbook of Railroad Information. Eastern Railroad Presidents Conference, New York 6, 1955. 100 pp.

Alameda County Mosquito Abatement District. 24th annual report, 1954. The County, Oakland, Calif., 1955. 20 pp.

Re-analysis of Existing Wave Force Data on Model Piles. Tech. Memo. No. 71. 19 pp. **Graphical Approach to the Forecasting of Waves in Moving Fetches.** Tech. Memo. No. 73. 31 pp. Beach Erosion Bd., Office of the Chief of Engineers, Dept. of the Army, Washington 25, 1955.

Converting Low-Grade Hardwood Stands to Conifers in the Arkansas Ozarks. Bull. 551. Fayette M. Meade. Agr. Expt. Sta., Univ. of Arkansas, Fayetteville, 1955. 26 pp.

Insect Homes. Cornell Rural School Leaflet, vol. 47, No. 3. 1954. 32 pp. **Summer Nature Explorations.** vol. 48, No. 4. 1955. 32 pp. New York State College of Agriculture, Cornell Univ., Ithaca.

Disposal of Government-Owned Communities at Oak Ridge, Tenn., and Richland, Wash. Joint Committee on Atomic Energy, Washington 25, 1955. 43 pp.

Les Esturgeons du fleuve Saint Laurent en comparaison avec les autres especes *d'Acipenserides*. Peche, biometrie, croissance, age, migration, pisciculture. Georges Roussow. Office de Biologie, Ministere de la Chasse et des Pecheries, Province de Quebec, Montreal, 1955. 124 pp.

Trends in Land Acquisition. Highway Research Bd., Bull. 101. 82 pp. $1.50. **Nonprofit Research and Patent Management Organization.** Publ. 372. Archie M. Palmer. 150 pp. $2. Natl. Acad. of Sciences–Nat. Research Council, Washington 25, 1955.

Navaho Acquisition Values. Rpt. of Rimrock Project Values Ser. No. 5. vol. XLII, No. 3. Richard Hobson. Peabody Museum, Harvard Univ., Cambridge, Mass., 1954. 37 pp. $1.10.

Psycholinguistics. A survey of theory and research problems. Report of 1953 summer seminar sponsored by Committee on Linguistics and Psychology of the Social Science Research Council. Charles E. Osgood and Thomas A. Sebeok, Eds. Indiana Univ., Bloomington, 1954. 203 pp. Subscription, $4.

Rapport sur le fonctionnement technique en 1953. J. Fournier and P. De Lajudie. Institut Pasteur de Saigon, Saigon, Viet-Nam, 1954. 174 pp.

The Genus *Oreomyrrhis* (Umbelliferae). A problem in Pacific distribution. Mildred E. Mathias and Lincoln Constance. Publ. in Botany, vol. 27, No. 6. Univ. of California Press, Berkeley and Los Angeles, 1955. 69 pp. $1.

Mycobacterium Tuberculosis: Bacteriology, Biochemistry, Laboratory Diagnosis and Chemotherapy. Milton Gross. The author, Jersey City, N.J., 1955. 41 pp. $1.

The Cepheid Variables and RR Lyrae Stars. Annals of the Astronomical Observatory of Harvard College, vol. 113, No. 3. 33 pp. **The Red Variable Stars.** No. 4. 18 pp. Cecilia Payne-Gaposchkin. The Observatory, Cambridge. 1954.

Manpower Resources in the Biological Sciences. A study conducted jointly by National Science Foundation and U.S. Dept. of Labor, Bureau of Labor Statistics. The Foundation, Washington 25, 1955 (Order from Supt. of Documents, GPO, Washington 25). 53 pp. 40¢.

Douze notre dix futur. Jean Essig. Dunod, Paris, 1955. 167 pp.

The National Research Council of Canada. Booklet describing organization and work of the Council. The Council, Ottawa, 1954. 19 pp.

The Bulletin of the Beach Erosion Board. vol. 9, No. 2. The Board, Office of the Chief of Engineers, Dept. of the Army, Washington 25, 1955. 13 pp.

Report of the Comptroller General of the U.S. on Atomic Energy Commission Contracts for Electric Power. pt. I. Review of Ebasco Services, Inc., performance at Joppa, Ill., Steam Electric Station of Electric Energy, Inc. Joint Committee on Atomic Energy, Washington, 1955. 27 pp.

The Stone Age Races of Northwest Africa. Bull. No. 18. L. Cabot Briggs. Peabody Museum, Cambridge, 1955. 98 pp. $1.

The Medical Significance of Anxiety. Richard L. Jenkins. Biological Sciences Foundation, Washington, 1955. 46 pp. $1.

Effect of Fine Particle Sizes on Sulfide Flotation. Quarterly of the Colorado School of Mines, vol. 50, No. 2. The School, Golden, Colo., 1955. 37 pp. $1.

Planning for Talented Youth: Considerations for Public Schools. Publ. 1. A. Harry Passow, Miriam Goldberg, Abraham J. Tannenbaum, and Will French. Bur. of Publications, Teachers College, Columbia Univ., New York, 1955. 84 pp. $1.

Comptes rendus du Comité National Francais de Géodésie et Géophysique; année 1952. A. Gougenheim. Secretariat General du Comité Francais, Paris, 1953. 224 pp.

Records of Oceanographic Works in Japan. vol. 2, No. 1. Pacific Science Liaison Committee. Japanese Natl. Commission for UNESCO, Tokyo, 1955. 213 pp.

Les propriétés des copals du Congo belge en relation avec leur origine botanique. Série Technique, No. 44. L. Hellinckx. L'Institut National pour l'Etude Agronomique du Congo Belge, Brussels, 1955. 42 pp. Illus. F. 40.

First Technical Progress Report Covering Work Done in 1954. Rpt. 4. Air Pollution Foundation, Los Angeles, 1955. 89 pp.

Bibliography on Southwestern Asia: II. A second compilation. Henry Field. Univ. of Miami Press, Coral Gables, Fla., 1955. 126 pp.

Tests on Large Culvert Pipe. Highway Res. Bd, Bull. 102. Natl. Acad. of Sciences–Natl. Research Council, New York, 1955. 18 pp. $0.45.

Speak Truth to Power. A Quaker search for an alternative to violence. American Friends Service Committee, New York, 1955. 72 pp. $0.25.

Dust Insecticides for the Control of the Imported Cabbage Worm. Bull. 590. G. A. Wheatley. Connecticut Agr. Expt. Sta., New Haven, 1955. 15 pp.

How Damage to Balsam Fir Develops after a Spruce Budworm Epidemic. Sta. Paper No. 75. Thomas F. McLintock. Northeastern Forest Expt. Sta., Upper Darby, Pa., 1955. 18 pp.

Radiation and Monitoring Fundamentals for the Fire Service. International Assoc. of Fire Chiefs, New York 1, rev. ed., 1955. 72 pp.

Scientific Meetings

Physical Anthropologists

The 24th annual meeting of the American Association of Physical Anthropologists was held in Philadelphia, 4–6 Apr. 1955, at the Jefferson Medical College, immediately before the meetings of the American Association of Anatomists. Two sessions were held jointly with the anatomists on 6 Apr. On 5 Apr, a symposium on human genetics and race (Spuhler, chairman) was held at the Wistar Institute, and a symposium on anthropology and medical education (Lasker, chairman) was held at the University Museum of the University of Pennsylvania. As a discussion preparatory to the section on anthropology in the forthcoming 1955 Teaching Institute of the Association of American Medical Colleges, this symposium showed the growth of physical anthropology stimulated by the relative vacuum between the fields of anatomy, genetics, physiology, medicine, and the social sciences. This theme was spelled out by retiring president William L. Straus, Jr., in his address at the annual dinner on "The training of the physical anthropologist." Straus asked for a swing away from the tradition of training first as "the compleat anthropologist" toward a primary training in the full depth and breadth of biology (from genetics to pathology) with the eventual aim of analyzing the forces that underlie the morphology which now provides most of our measurable data.

W. M. Krogman and his staff at the Philadelphia Center for Research in Child Growth staged an informative and well-attended demonstration of their techniques and results. At the University Museum the American Institute of Human Paleontology exhibited (Eiseley) the collection of casts of remains of fossil man which the museum offers at cost to interested institutions or individuals. This service was made possible by purchase of the Barlow collection of molds through the generosity of the Wenner-Gren Foundation [*Science* **120**, 7A (1954)].

Out of 48 papers and demonstrations at least 20 were primarily anatomical, dealing in some cases with soft tissue form (Hertzberg and Saul, R. Newman, Baker), growth (Noback), or pathology (Michels, Papez). But more papers dealt with bone, again in relation to form and function (Dempster, Miles and Sullivan, Hutchinson, Howell, Evans), growth processes and aging (Stewart, Cobb, Angel, Moss, Hurme) including such aspects of bone physiology as ash-weight (Trotter), and pathology (Angel, Stewart, Thieme, Goff). Further aspects of growth were discussed by Sarnas and Asling (skull in men and in rats, respectively), Krogman, Swindler, and Gerald (child growth), Schulman (Israel), Garn (tissue-mass radiography related to age and hormones), and Gavan and van Wagenen (macaques).

Hertzberg and Saul's applied study of face form and R. Newman's and Baker's discussions of fat deposition and body composition related to climate fitted in with less adaptively specific papers on race and evolution (Gusinde, Neumann, M. Newman, Eiseley, Howell, Straus). It is significant that this central stronghold of physical anthropology was no more stressed than the area of human genetics with a pedigree paper (DePena) and discussion of blood-group distributions (Hulse, Fry) in addition to papers of Hunt, Dunn, Ceppelini, and Spuhler that made population genetics the main issue of the first symposium. Sutton entered into this creatively with work on tissue-fluid differences among populations (paper chromatography). This biochemical approach was carried in a nongenetic direction by Thieme with work on detection of syphilis in bone.

Much of the second symposium, on medical education, stressed the value of the statistical approach in the areas of growth, variation, and population studies (Garn, Greulich, Angel, Krogman, Lasker). But Paul's contribution, on the interrelationship between the cultural dimension, biology, and the psychological dimension in any disease or syndrome brought in the personal element in the socialization of a future doctor and, hence, led to a broader discussion.

Churchill's and Spuhler's expositions of statistical applications to body variation and to human genetics carried this approach further than could a symposium. Primary dependence on statistical interpretation also marked the two papers in pure social biology (Aginsky on mating patterns and Goldstein on critique of survival of the unfit). These, plus the papers of Paul, Dunn, and Hulse, stressed the substantial nature of the root that physical anthropology has in the behavioral sciences. Furthermore, in attendance were representatives of social anthropology, of medical specialties such as orthopedics, gynecology, and radiology, of the orthodontic field, and of the biological fields ranging from genetics to neurophysiology.

The association's newly elected president, Mildred Trotter, is an anatomist and is also the first woman to serve as president in the quarter-century of the association's existence. W. W. Howells, retiring editor of the *American Journal of Physical Anthropology*, was elected to the executive committee. Howells, who succeeded the late E. A. Hooton as professor of anthropology at Harvard a year ago, is the 1954 winner of the Viking Fund Medal and Award in Physical Anthropology given annually by the Wenner-Gren Foundation for Anthropological Research. S. L. Washburn of the University of Chicago follows Howells as editor of the journal, which is published by the Wistar Institute. Appreciation was expressed to E. J. Farris for his skill and foresight in directing the Wistar Institute and its scientific press.

An important step taken at the business meeting was the decision to support Section H of the AAAS in its decision to withdraw from the 1955 meetings of the AAAS scheduled to be held in Atlanta, Georgia, a city where racial segregation is still in force. The membership of the AAPA voted unanimously to adopt the following resolution, proposed by W. W. Howells as the association's representative to the AAAS.

"Whereas the American Association of Physical Anthropologists cannot by principle hold meetings or participate in meetings in places where racial segregation is practiced, be it resolved that the Association hereby associate itself with the action of the committee members of Section H in declining to participate in the meetings of the AAAS in Atlanta in 1955."

This action followed a careful and full review of the situation regarding the Atlanta meetings by W. M. Cobb, chairman of Section H and vice president of the AAPA, and a searching and sympathetic discussion of Cobb's data. It was clear from this discussion that the members of the American Association of Physical Anthropologists are fully alive to the need for a drive to end all types of segregative practices if scientific endeavor is to flourish.

J. Lawrence Angel

Daniel Baugh Institute of Anatomy, Jefferson Medical College, Philadelphia, Pennsylvania

■ An invitational conference on Recent Advances in the Physiology of the Invertebrates, sponsored by the National Science Foundation, the Tektronix Foundation, and the University of Oregon, will be held at Eugene, Ore., 12–16 Sept. The conference was initiated by A. W. Martin of the University of Washington and has been organized by a committee composed of Martin, L. H. Kleinholz of Reed College, B. T. Scheer of the University of Oregon, and T. H. Bullock of the University of California.

The conference will consist of a series of reviews, which are to be published, followed by informal discussions. A visit to the Oregon Institute of Marine Biology at Charleston is planned. Among those who have already agreed to participate, besides the committee, are F. A. Brown, Jr., J. S. Pringle, J. D. Robertson, T. H. Waterman, C. A. G. Wiersma, and K. M. Wilbur. Interested persons should write to Scheer.

■ The annual meeting of the Society of General Physiologists will be held 9–10 Sept. at the Marine Biological Laboratory, Woods Hole, Mass. A feature of the meeting will be a symposium on *Physiological Triggers,* organized by T. H. Bullock of the University of California at Los Angeles. For information write to the secretary-treasurer of the society, John Buck, National Institutes of Health, Bethesda 14, Md.

■ The five congress lectures that head the extensive program for the 14th International Congress of Pure and Applied Chemistry that is to take place in Zurich, Switzerland, 21–27 July are as follows: V. du Vigneaud, Cornell University, New York, "Oxytocin, the principal oxytocic of the posterior pituitary gland: isolation, structure, and synthesis"; C. Dufraisse, Collège de France, Paris, "La photooxydation"; N. A. Nesmejanow, Académie des Sciences, Moscou, "Zweifache Reaktionsfähigkeit und Tautomerie"; C. K. Ingold, University College of London, "Developments in the theory of steric hindrance"; K. Alder, Universität Köln, "Neuere Entwicklung der Dien-Synthese."

■ The 10th annual Calorimetry Conference is scheduled to meet at the University of Minnesota, 16–17 Sept. As in the past, this meeting will bring together various scientists—chemists, metallurgists, physicists, and others—who utilize the various methods and techniques of calorimetry. The conference will be devoted in part to such topics as very low temperature calorimetry, liquid-helium calorimetry, high- and low-temperature adiabatic calorimetry, measurements of stored energy in solids and related topics, high-precision bomb calorimetry, measurements of heats of solutions and heats of precipitation, both for liquid-solid and solid-solid temperatures, and so forth.

In addition, the conference concerns itself with standard calorimetric samples, symbols and terminology, and the promotion of better instrumentation and publication policies pertinent to thermodynamics data. The various topics may be presented as individual reports as round-table discussions, or as committee reports. The chairman of the 1955 meeting is Warren DeSorbo of the General Electric Co., and the program chairman is Edgar F. Westrum, Jr., of the University of Michigan.

Society Elections

■ American Board of Clinical Chemistry, Inc.: pres., Marschelle H. Power; v. pres., Clarence W. Muehlberger; sec.-treas., Oliver H. Gaebler, Henry Ford Hospital, Detroit 2, Mich.

■ Society for Investigative Dermatology, Inc.: pres., J. Lamar Callaway, Duke University; v. pres., Sture A. M. Johnson, 313 New Castle Way, Madison, Wis.; sec.-treas., Herman Beerman.

■ Illinois State Academy of Science: pres., Leland Shanor, University of Illinois; 1st v. pres., Joan Hunter, Edwardsville High School; 2nd v. pres., Glen S. Winterringer, State Museum; sec., Lyle E. Bamber, University of Illinois; treas. (pro-tem), James W. Neckers, Southern Illinois University. Representative to the AAAS council is Percival Robertson, The Principia.

■ American Psychosomatic Society: pres., Stanley Cobb; pres.-elect, I. Arthur Mirsky; sec.-treas., Theodore Lidz, APS, 551 Madison Ave., New York 22.

■ American Academy of Dental Medicine: pres., S. Leonard Rosenthal, Temple University; pres.-elect, William M. Greenhut, Mount Vernon, N.Y.; v. pres., Marcel B. Archambault, Montreal, Canada; sec., G. J. Witkin, Yonkers, N.Y.; treas., George G. Stewart, Philadelphia, Pa.

■ The Meteoritical Society: pres., D. Moreau Barringer, Barringer Crater Co., 1526 Chestnut St., Philadelphia 2, Pa.; sec., John A. Russell, University of Southern California, 3518 University Ave., Los Angeles 7; treas., Paul W. Healy, Department of Mathematics, University of New Mexico. The vice presidents are Carl W. Beck, Department of Geology, Indiana University; Dorrit Hoffleit, Harvard College Observatory; and Stuart H. Perry, Adrian, Mich. Beck is representative to the AAAS council.

■ West Virginia Academy of Science: pres., A. C. Blackwell, Morris Harvey College; past pres., A. R. Collett, West Virginia University; pres.-elect, James T. Handlan, Jr., Potomac State College; sec., Max Ward. Glenville State College; treas., H. D. Bennett, West Virginia University.

■ Kansas Academy of Science: pres., D. J. Ameel, Kansas State College; pres.-elect, H. S. Choguill, Fort Hays Kansas State College; v. pres., W. H. Horr, University of Kansas; sec. and representative to the AAAS Council, C. T. Rogerson, Kansas State College; treas., Standlee Dalton, Fort Hays Kansas State College.

■ North Carolina Academy of Science: pres., E. C. Cocke, Wake Forest College; v. pres., H. W. Jensen, Warren Wilson College; sec.-treas. and representative to the AAAS Council, John A. Yarbrough, Meredith College.

■ Louisiana Academy of Sciences: pres., E. C. Greco, United Gas Corp., Shreveport; past pres., W. G. Erwin, Northwestern State College; pres.-elect, H. E. Wheeler, Louisiana State University; sec.-treas., Roland Abegg, Southeastern Louisiana College; permanent sec., H. B. Boudreaux, Louisiana State University. Representative to the AAAS Council is Ellinor H. Behre, Louisiana State University.

■ National Speleological Society: pres., William E. Davies, 125 W. Greenway Blvd., Falls Church, Va. The vice presidents are Burton S. Faust, Joseph D. Lawrence, Jr., Jerome M. Ludlow, Albert C. Mueller, Jr., Brother G. Nicholas.

■ National Association of Boards of Pharmacy: pres., Wilbur E. Powers, Rockefeller Center, 610 Fifth Ave., New York 20; v. pres., Howell R. Jordan; sec., P. H. Costello, 77 W. Washington St., Chicago 2; treas., Robert L. Swain.

■ National Association for Research in Science Teaching: pres., William C. Van Deventer, Western Michigan College of Education; v. pres., Waldo W. E. Blanchet, Fort Valley State College; sec.-treas., Clarence M. Pruitt, University of Tampa. Representative to the AAAS Council is George G. Mallinson.

■ American College of Apothecaries, Inc.: pres., Mearl D. Pritchard, Buffalo, N.Y.; pres.-elect and representative to the AAAS Council, Leroy Weidle, Jr., St. Louis, Mo.; v. pres., Calvin Berger, New York; sec., Robert E. Abrams, 39th and Chestnut St., Philadelphia 4, Pa.; treas., Charles V. Selby, Clarksburg, W. Va.

Forthcoming Events

August

1–5. American Oil Chemists' Soc., short course on analytical techniques, Urbana, Ill. (L. R. Hawkins, 35 E. Wacker Dr., Chicago 1, Ill.)

1–5. International Cong. of Plastic Surgery, Stockholm and Uppsala, Sweden. (J. F. Larsen, 12, Kristianiagade, Copenhagen Ø, Denmark.)

1–6. International Cong. of Biochemistry, Brussels, Belgium. (C. Liebecq, 17 Place Delcour, Liége, Belgium.)

3–7. International Meeting of Neurobiologists, Groningen, Netherlands. (J. A. Kappers, Dept. of Anatomy and Embryology, Oostersingel 69, Groningen.)

5–6. Pennsylvania Academy of Science, University Park, Pa. (K. Dearolf, Public Museum and Art Gallery, Reading, Pa.)

6–7. Linguistic Soc. of America, Washington, D.C. (A. A. Hill, 1719 Massachusetts Ave., NW, Washington, D.C.)

6–7. Minnesota Acad. of Science, Pipestone, Minn. (B. O. Krogstad, Science and Mathematics Div., Univ. of Minnesota, Duluth 5.)

8–10. Inst. of Aeronautical Sciences, Seattle, Wash. (S. P. Johnston, IAS, 2 E. 64 St., New York 21.)

8–13. International Council of Scientific Unions, Oslo. (Admin. Secretariat, ICSU, 29 Tavistock Sq., London, W.C.1.)

8–20. International Conf. on the Peaceful Uses of Atomic Energy, Geneva, Switzerland. (W. G. Whitman, Room 3468, United Nations, New York.)

12–17. Canadian Teachers' Federation, Ottawa. (G. G. Croskery, 444 MacLaren St., Ottawa, Ont.)

15–16. Operations Research Soc. of America, 7th national, Los Angeles, Calif. (R. A. Bailey, Military Operations Research Div., Lockheed Aircraft Corp., Burbank.)

15–18. American Veterinary Medical Assoc., Minneapolis, Minn. (J. G. Hardenbergh, 600 S. Michigan Ave., Chicago 5, Ill.)

15–19. American Institute of Electrical Engineers, Pacific general, Butte, Mont. (N. S. Hibshem, 33 W. 39 St., New York 18.)

15–19. American Soc. of Agronomy and the Soil Science Soc. of America, joint meeting, Davis, Calif. (L. G. Monthey, 2702 Monroe St., Madison 5, Wis.)

15–19. Plant Science Seminar, 32nd annual, Gainesville, Fla. (C. H. Johnson, School of Pharmacy, Univ. of Florida, Gainesville.)

15–20. International Dental Federation, 43rd annual, Copenhagen, Denmark. (W. R. Klausen, 1 Alhambravey, Copenhagen V.)

17–24. Australian and New Zealand Assoc. for the Advancement of Science, 31st, Melbourne, Australia. (J. R. A. McMillan, ANZAAS, Science House, 157 Gloucester St., Sydney, N.S.W., Australia.)

17–9. Canadian Mathematical Cong., 5th summer seminar, Winnepeg, Manitoba. (Secretariat, CMC, Chemistry Bldg., McGill Univ., Montreal.)

19–28. International Conf. of Agricultural Economists, Helsingfors, Finland. (J. R. Currie, Dartington Hall, Totnes, Devonshire, Eng.)

19–30. National Assoc. of Biology Teachers, Ann Arbor, Mich. (P. V. Webster, Bryan City Schools, Bryan, Ohio.)

22–25. Electronics and Automatic Production Symposium, San Francisco, Calif. (Wm. D. McGuigan, Stanford Research Inst., Palo Alto.)

22–9. Wool Textile Research Conf., Sydney, Australia. (F. G. Nicholls, Commonwealth Scientific and Industrial Research Organization, 314 Albert St., East Melbourne, Australia.)

29–31. American Physical Soc., Mexico City, Mexico. (K. K. Darrow, Columbia Univ., New York 27.)

29–2. Infrared Spectroscopy Inst., 6th annual, Nashville, Tenn. (N. Fuson, ISI, Fisk Univ., Nashville 8.)

29–2. International Assoc. for Hydraulic Research, 6th plenary, Delft, Netherlands. (L. G. Straub, St. Anthony Falls Hydraulic Lab., Minneapolis 14, Minn.)

29–3. Mathematical Assoc. of America, Ann Arbor, Mich. (H. M. Gehman, Univ. of Buffalo, Buffalo 14, N.Y.)

(See issue of 17 June for more comprehensive listings.)

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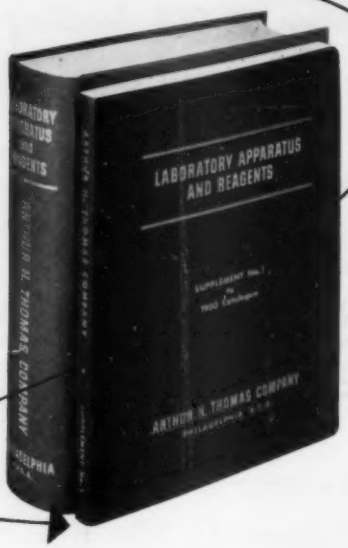

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